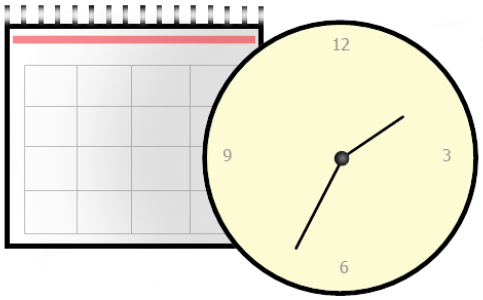
Flexible Duty Roster for Doctors in Hospitals



TDT4290 Customer Driven Project

Arve Nymo Skogvold
Thorbjørn Sæther
Susanne Sousa Moseby
Petter Westby
Even Bruvik Frøyen

Fall 2009

Preface

This report is the result of a group assignment in the course TDT4290 Customer Driven Project at the Norwegian University of Science and Technology. It was carried out by group 3 during the autumn of 2009. The group consisted of five students from the Department of Computer and Information Science.

Our assignment, given by the Ear, Nose and Throat (ENT) Department at St. Olavs Hospital, was to make a program that could assist the department in creating a work schedule for the doctors. This scheduling was done manually, and was very time consuming. Our program should be able to do the regular scheduling automatically, given a number of constraints given by the customer. Irregularities, like when an employee is absent, will be resolved manually. By inserting these resolutions back into the system, it should be able to continue with the regular scheduling.

We would like to offer our gratitude to our supervisors Basit A. Khan and Andreas Landmark for their invaluable feedback and support from day one and throughout the project.

We would also like to thank the customer representatives Ellen Jaatun and Leif Anders Holmen for their trust and prompt communication during the project.

Even Bruvik Frøyen Susanne Sousa Moseby

Petter Westby Thorbjørn Sæther

Arve Nymo Skogvold

Abstract

The current method for planning shifts at the St. Olavs Hospital university hospital in Trondheim is a manual process, requiring several hours per week due to small alterations and unnoticed conflicts. There are several constraints involved with different tasks and work hours. Shifts have to be fairly distributed to the junior doctors, junior doctors being attached to a supervisor for shifts, and constraints apply on the length of period a doctor is allowed to work uninterrupted.

The employees associated with this work in the Ear, Nose and Throat department of the hospital expressed an interest in a partially automated solution to this task, in an effort to reduce the amount of work and time spent. They indicated that other departments had similar issues, and might as such also be interested in any product solving this problem.

A web application was designed and implemented by this group in accordance with the requirements set forth by the customer. An effort was also made to make the design as flexible as possible, enabling other departments to utilize the finished product as well. Design and implementation was performed over four iterations, using an agile software development method.

Due to time and resource constraints, certain low priority, nice-to-have requirements were not implemented, but the system was designed to be easy to extend and modify. The system was not believed to be fully portable between domains in its current incarnation, but was considered by the group to be a solid proof of concept.

Testing has indicated that the resultant product could prove usable for the Ear, Nose and Throat department of the hospital. The project group would expect a significant decrease in the time spent on scheduling shifts at this department.

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CHAPTER 1

Introduction

Scheduling shifts is a tiresome and time consuming task in any business, and particularly in hospitals where errors are costly, rules are plentiful and changes are rapid. The person performing this function will have to keep track of all the employees, distributing hours fairly and avoiding collisions. Rules regulating working hours and breaks have to be followed and the qualifications of individual employees need to be paid attention to. Errors result in jobs not being done and in operations and procedures being delayed or rescheduled, affecting not just the employees of the hospital but also the patients. Hours are spent every day on this task in every department, and it is a job nobody wants to do.

In many ways, this task lends itself to automation. While the many rules and constraints will make the tasks daunting and frustrating to a human being, it also results in a well defined rule set for a scheduling algorithm. Though it is difficult to create an algorithm to generally schedule something optimally, a number of constraints and rules will make the job easier and reduce the run time of the necessary computations.

We have been given the task of trying to implement this automation. This project goal is to create a tool to automate large parts of this onerous process as requested by the St. Olavs hospital Ear, Nose and Throat department. Many schedulers have been created in the past, with varying levels of success, and were generally domain specific, as will this scheduler be. It will be designed to be used specifically for scheduling the work of doctors and assistant doctors within a single department of a hospital, although we expect it to be transferable to all departments in any Norwegian hospital with some adjustments.

1.1 Project Description

In this section, we will make a top level introduction of the project, including the project name, sponsor and stakeholders.

1.1.1 Project Name

The given project name was *Flexible duty roster for doctors in hospitals*. As this name is both long and not very easy to remember, we had a meeting to brainstorm for new names.

Khronos refers to the Greek god who is the personification of time. He arose from the original *chaos*, and is often depicted as an old, gray-haired man with a long beard. His name literally means *time* in Greek. We chose this name as it is easy to remember and relevant to the project goal.

1.1.2 Project Sponsor

The project sponsor is the Ear, Nose and Throat (ENT) (Øre-Nese-Hals) department at St. Olavs Hospital, a university hospital serving the health care needs of central Norway. St. Olavs Hospital is the public hospital of the whole of Sør-Trøndelag, it was first built in 1902 and is today one of the most modern hospitals in Northern Europe. The hospital has only had its "St. Olav" name since 2001, when it was changed from "Regionsykehuset i Trondheim". The new name marked the new plans of building a new and modern university hospital.

1.1.3 Project Mandate

Purpose

Our assignment is to develop a program for scheduling the work hours of doctors and doctors in training at the ENT department at St. Olavs Hospital, Trondheim. Currently, the department uses a manual scheduling system where a secretary uses around 30 minutes every single day to resolve conflicts and find replacements. This is both time consuming and error prone, as it can be difficult to see if one person has been set to be in two places at one time.

Objective

The main objective of this project is to make a program which can assist the staff in the task of planning the work schedule. The program should only take care of the long term planning, i.e. one to three months in advance. Changes because of sickness or other sudden reasons, should be dealt with by the staff — because otherwise, there would be a much greater need for domain knowledge, more than the resources of this project will allow.

We intend to deliver the program to the customer, prior to the final presentation. This way, it can be tested by the customer, so that they could give feedback before the presentation. Read Section 3.2.1 for more information on the development model.

1.1.4 Stakeholders

These are the stakeholders of the project:

Project Group

- Even Bruvik Frøyen - evenbf α gmail.com
- Susanne Sousa Moseby - susannemoseby α gmail.com
- Arve Nymo Skogvold - arve.kpro α skogvold.org
- Thorbjørn Sæther - thorbjsa α gmail.com
- Petter Westby - kpro α pwestby.com

Customer

- Ellen Jaatun - ellen.jaatun α stolav.no
- Leif Anders Holmen - leif.holmen α stolav.no

Supervisors

- Basit Ahmed Kahn - basit α idi.ntnu.no
- Andreas Landmark - andreala α idi.ntnu.no

Others

- The end users

1.1.5 Problem Description

There are two main categories of personnel who are to be included in the plans generated: senior doctors and junior doctors. The main difference between them is that the senior doctors have a fixed working schedule. They have the same working hours from day to day, and do not work night shifts. They do, however, have to be on-call — one senior doctor every day. This means they are home at night, but must sometimes respond to emergencies, and show up on short notice.

Junior doctors do work night shifts — one junior doctor at a time. These shifts are split up in the different week-days, but week-end duty goes from Friday to Sunday. When working the night shift, a doctor works from 18:00 to 08:00 the next day. For obvious reasons, this means they will not work the following day. As the regular working hours are from 07:50 to 16:00, there is a need for a short shift between 16:00 and 18:00. This is also considered an extra shift, and should be distributed fairly.

During normal working hours, a junior doctor should usually be assigned to a supervising senior doctor and follow his schedule.

Every week, one junior doctor and one senior doctor have a special kind of shift. Their tasks then are to follow up on admitted patients and other administrative work. During this shift, they should not be assigned to any other tasks.

CHAPTER 2

Project Management

In this chapter we describe how we choose to organize the project. We distribute roles among the group members, and we set up a time schedule for the different milestones. A work breakdown structure and risk analysis are also provided, along with procedures for quality assurance.

2.1 Project Organization

This section introduces the basic project structure, including the project members and their roles. It also contains the project time plan, along with the work breakdown structure and risk analysis used as the basis for the plan.

We will use the Scrum framework as development model for the project, as described in Section 3.2.1. This introduces a flat structure, as all project members join the scrum team, and take tasks off the backlog.

2.1.1 Roles

Although we have a flat structure, the members will also have different roles outside the Scrum organization. Table 2.1 shows who has which roles.

Arve Skogvold	Project manager, Customer contact
Even Bruvik Frøyen	Research manager
Susanne Sousa Moseby	Secretary, Supervisor contact
Thorbjørn Sæther	QA manager, Scrum master
Petter Westby	Document owner, Test manager

Table 2.1: Roles

Project Manager

The project manager is responsible for the progress of the group. He is responsible for calling the group together, and setting up the working organization.

As the project enters the Scrum phases, the sprints, the project organization will be flatter and the role of the project manager will be more like a regular project member. We have, however, also assigned him the role as the Scrum "product owner". He will represent and make decisions on behalf of the customer, to make sure the most important parts of the project are given priority.

Customer Contact

Point of contact for the customer. The customer will send all mail to this person (or the mailing list). The customer contact is then responsible for distributing information to the rest of the group. He coordinates meetings with the customer, making sure the group and customer all know where and when to meet.

Normally, the customer contact is the only person sending mail to, or in any other way contacting the customer. This is to make sure that the customer does not get conflicting messages, or is inconvenienced by having to answer the same questions several times.

Scrum Master

The Scrum master is responsible for overseeing the Scrum usage of the team and enforcing the rules of the process. He is a facilitator, and should keep distracting influences away from the team so they can focus on the task at hand.

Research Manager

In charge of doing research on existing staff scheduling software, and applicable programming frameworks. He shows the group his results, gives information about relevant existing software, and recommends frameworks to be used during the project.

Secretary

Writes minutes from customer- and supervisor meetings. Keeps track of hour registration.

Supervisor Contact

In charge of communications with supervisor. Sends agenda / minutes for supervisor meetings.

Quality Assurance Manager

In charge of quality assurance, and making sure that the group follows the routines agreed upon. Following up on document templates and response times are examples of his work.

Document Owner

Responsible for the progress of the project report. Making document procedures. Keeps track of what documentation is missing, so that the whole group has a better picture of what they have to do. He is not supposed to write most of the report on his own, but must have good overview of what needs to be done.

Test Manager

In charge of the tests that will be used to ensure that the program works according to our claims. Alerts others about regressions detected during testing.

2.1.2 Time Plan

We have set some milestones to follow. One of the rules in Scrum is to never extend a sprint, but rather postpone tasks. This means that even if the milestones are reached on the given dates, we could still have tasks left when moving to the next sprint.These milestones are reflected in the Gantt chart, as shown in Figure 2.1.

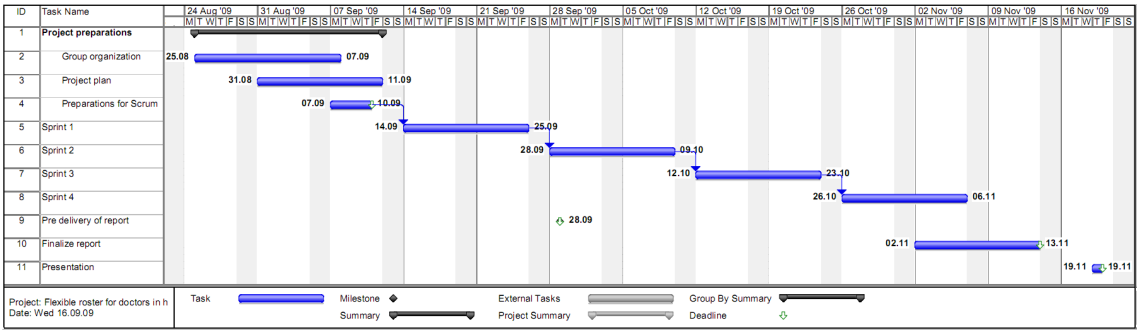

Figure 2.1: Gantt chart

2.1.3 Work Breakdown Structure

To prepare tasks for the initial backlog, we have set up a Work Breakdown Structure (WBS). This helps identifying the different tasks to do when implementing, and makes it easier to estimate how many working hours the different tasks will take. Figure 2.2 shows the WBS. It has been split in two to make it narrower, so that it can fit on a page.

We will not update the WBS throughout the project, as it is not a tool in Scrum. It was mainly made for making us aware of different subtasks when setting up the initial product backlog.

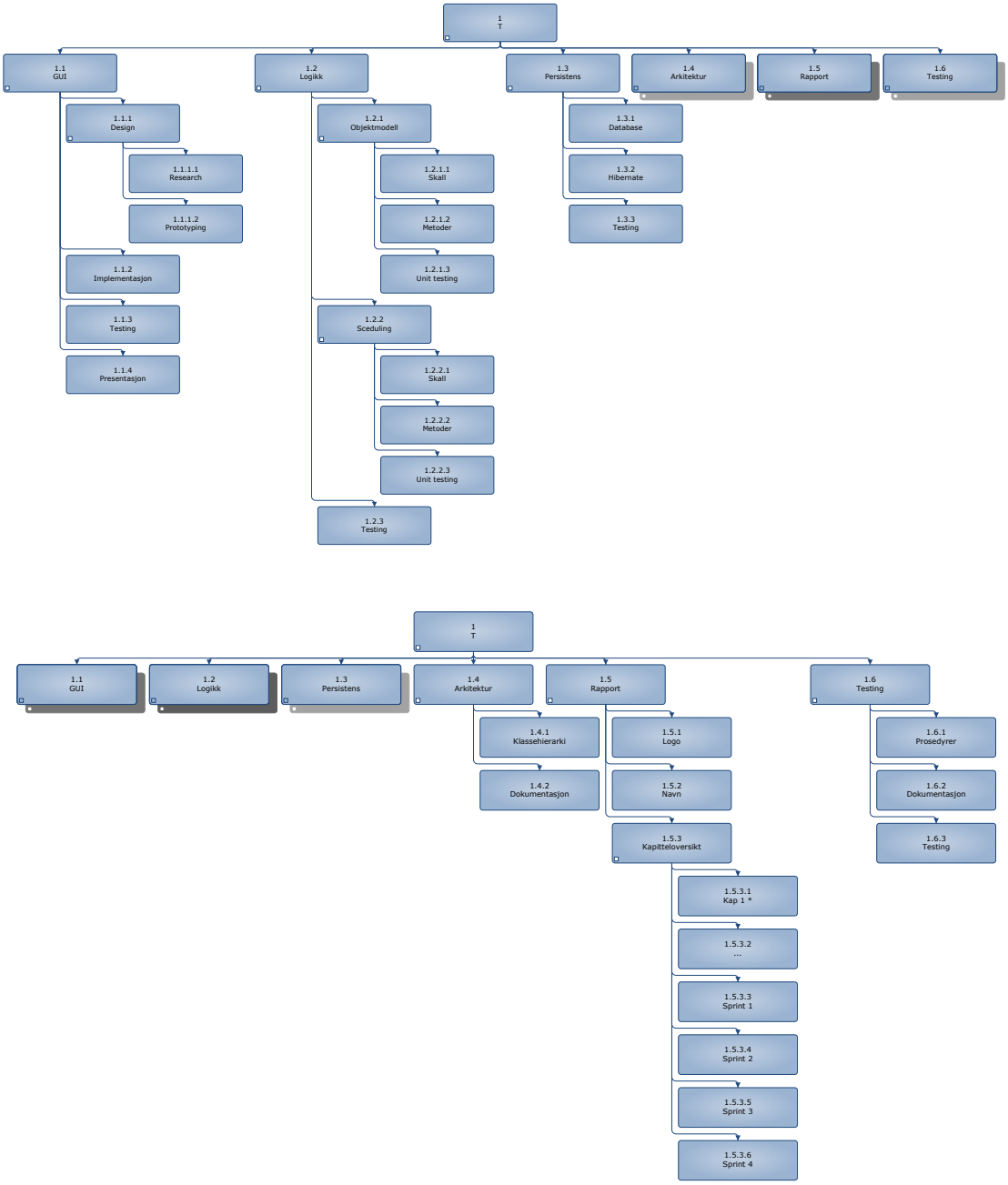

Figure 2.2: Work Breakdown Structure

We consider the project to consist of the following subtasks:

1. Khronos

   1.1 GUI, referring to the creation and testing of the user interface;

   1.2 Logic, referring to the creation and testing of the various logic entities needed, as well as the algorithms for their manipulation necessary for the system functionality;

1.3 Persistence, referring to the creation and testing of the database and the necessary control structures for the system's usage of said database;

1.4 Architecture, referring to the creation of a usable architecture that the system as a whole will follow, as well as the creation of the necessary documentation of said architecture;

1.5 Report, referring to the creation of the project's logo, name, and the report as a coordinated whole;

1.6 Testing, referring to the creation of the procedures and documentation of tests, as well as the testing of the system as a whole.

2.1.4 Risk Analysis

We have made a risk analysis for the project, which shows which risks might affect the success of the project. For every risk we have a table which explains what the risk is, how it might affect us, what we have done to avoid or limit the risk, and what we can do if the risk occurs. Then we have the *probability* and *damage*, which show in numbers from 1 to 10 how serious they are. 1 meaning not likely to happen / non-critical, 10 meaning very likely to happen / the damage is critical. The `Risk` from 1 to 100, shows the product of these two, and gives an impression on how serious the risk is and shows us what we should prioritize. The detailed risk analysis is shown in Appendix A. Table 2.2 shows a summary of the risk analysis.

Risk	**Probability**	**Damage**	**Risk**	**Responsibility**
Illness or other unexpected absence	4	6	24	everyone
Too much to do in other subjects	6	6	36	everyone
Lack of materials	2	4	8	secretary
Internal conflicts	2	6	12	everyone
External conflicts	2	8	16	customer contact
Internal misunderstandings	2	4	8	everyone
External misunderstandings	3	7	21	everyone
Security problems	6	8	48	system architects
Don't know how to use development tools	8	6	48	everyone

Table 2.2: Risk summary

2.2 Sprints

For our project we are using Scrum, an agile software development method. A wider explanation of Scrum can be found in Section 3.2.1. An essential part of Scrum is the sprints, and in this section we will explain the sprint meetings and how we organize them.

2.2.1 Sprint Planning Meeting

Every sprint starts with a planning meeting. In this meeting, the team members decide what we will produce during the sprint. We make these decisions based on the product backlog.

When we have decided what to accomplish, we break the work down into more manageable tasks. These tasks should not be too large, as they should be possible for one team member to finish in a timely manner. Some tasks, however, will remain large. These tasks are typically related to documentation.

After breaking down the work, we distribute the tasks among the team members. The distribution will be based on how long the tasks will take. Each team member looks at each task and gives a time estimate, then the team tries to reach consensus about the estimate. With time estimates, we ensure a fair distribution and lower the probability that any team member will have a lot more work to do than the others.

The tasks agreed upon become the basis of the sprint backlog, which is a detailed overview of the tasks and how long they will take to finish.

2.2.2 Daily Scrum

Although this meeting is normally performed every day during a sprint, we have decided we will have four meetings every week. Since the team members all have different lectures at different times, it is difficult to find room for more meetings.

The meetings will be held at the same time and location every day, except on Thursdays. The location is room 521 in the P15 building at NTNU. On Tuesdays, Wednesdays and Fridays the meeting will be held at 09.15, and at 10.15 on Thursdays. There will be no waiting for team members that are late.

The meetings will last about 15 minutes, and will be performed while standing in a semicircle around the planning board. This is because the daily scrums are supposed to be short and to the point, and the planning board shows the sprint plan and reminds everybody of the work that needs to be done. All stakeholders are welcome to attend these meetings, but only the scrum team and the product owner are allowed to talk.

The team members will answer to three questions during this meeting:

1. What have you done since yesterday?
2. What are you planning to do today?
3. Do you have any problems preventing you from accomplishing your goals?

After the meeting, the Scrum Master and other team members who choose so, will talk to members who answered anything but no to the third question and try to help. With these daily scrums, the state of progress is monitored. We present the sprint backlog tasks and the progress in the sprint burn down chart. It gives us a visualization of the work remaining and how our progress relates to the plan.

2.2.3 Sprint Review Meeting

This meeting is held after each sprint. In our project, this means 14 days after the planning meeting. In this meeting we discuss the work we have done in the sprint. We review both the completed work and what was not completed. If it is possible, we try to have the customer present at these meetings. This way, they can see how the project is progressing. If we have any completed work done, we can also demonstrate this to the customer. They are also welcome to comment on our work, offer suggestions on what they want us to do next and voice their opinion if there is something they are not happy with.

2.2.4 Sprint Retrospective

After the review meeting, which focuses on the work itself, we have a retrospective meeting. The intention of this meeting is to work on improving the process. The team members are the only participants and will discuss different aspects of the sprint, such as: What went well? What did not? Is there anything that can be improved in the next sprint?

2.3 Procedures for Quality Assurance

The purpose of this part is to define the routines the project group implemented to assure a high quality in the end result of the project.

2.3.1 Response Time

No formal agreement is made with either the supervisors or the customer, but we have made it clear that we will respond as fast as we can. The group members have exchanged phone numbers and MSN Messenger addresses, so contacting each other quickly is no problem.

2.3.2 Customer Meetings

No formal agreement has been made, but we aim to have a meeting at least every other week. We have also made it clear to the customer that they can visit us to observe the Scrum meetings or for any other reason they might want to. Notice shall be given at least the day before the meeting is held.

2.3.3 Supervisor Meetings

We have scheduled to have a meeting with the supervisors once a week. Minutes from the last supervisor and customer meeting will be attached to the invitation, which will be sent before 12:00 the day before the meeting will be held. The invitation will also include the agenda for the meeting, phase documents and the status report.

2.3.4 Coding Guidelines

Our group has chosen to adopt the Java coding conventions as published by Sun[1]. Some important points are summarized in Table 2.3.

Rule	Example
Constants are all upper-case. If consisting of several words, they are separated by underscore.	`VERSION_NUMBER`
Other identifiers consisting of several words are separated using mixed case — with the first letter of each word in upper-case.	`SeniorDoctor`, `getSumOfWorkingHours()`
Class names are named with nouns, and begin with upper-case letter.	`Person`
Methods are named with verbs, and begin with a lower-case letter.	`makeSchedule()`

Table 2.3: Some important coding guidelines

2.3.5 Subversion Procedures

To enable effective collaboration, avoid conflicting changes, and to make sure every project member has access to the latest version of the documents and code, we have set up a Subversion repository. See Appendix B for information on how to access the repository.

The following guidelines shall be followed.

- Before starting work, perform an SVN update.
- Sort out any conflicting changes.
- Do not commit code that breaks the build / report rendering.
- Commit frequently.
- Write good commit messages describing the modifications.
- Do not add unnecessary generated files (binary Java class files / different LaTeX generated files). One exception is the `report.pdf`, which can be uploaded whenever a related document is updated.

CHAPTER 3

Preliminary Studies

To try and resolve some concerns and get a better understanding of the project at hand, we did some preliminary work. This chapter will explain what the current situation is, and how it helps us how to proceed with the project. The tools we are most likely to use throughout the process are also described.

3.1 The Situation Today

The current situation, when it comes to scheduling programs and algorithms, must naturally be considered in a project of this kind. Several questions need to be answered before we start implementing, such as whether there is a need for the project at all — maybe existing programs already fulfill the customers requirements, and if there is a need, what algorithms have already been developed that can be used to solve these problems. Not considering such questions can result in our project spending time reinventing an existing solution.

3.1.1 Existing Programs

There are several commercial programs in the field of scheduling on the market as this is being written. However, they do not cover the needs expressed by the customer for this project. Some are designed to ease the task of scheduling by helping the user identify possible errors or problems rather then actually scheduling. One example is Time Tracker from Asgard Systems Inc[1].

Others are designed to ease self scheduling and interoperability between HR systems[2]. Furthermore, most are designed for scheduling shifts for nurses rather than doctors. While the principles are transferable, this involves domain differences which may require costly adaptation work. General schedulers are available[3], but these are designed to be utilized in a large field of businesses, and will require much work to adapt to hospital use.

As an example, consider the Visual Staff Scheduler[2], a scheduling tool boasting a wide range of positive feedback from the healthcare industry. It allows the user to add attributes such as certifications and specialties to employees; it tracks the employees' total working hours so far in a period, as a percentage of a total workload

[1] `http://www.asgardsystems.com/`
[2] `http://www.res-q.com/`
[3] `http://www.timeclockplus.com/`

if desired; it lets you group employees who should ideally work together; it lets you export the resulting schedule, easing distribution. It reduces errors and conflicts, and reduces overtime expenses. While these are all helpful functions which our customer might like, this system does not perform the primary function desired by the customer, namely automatic and flexible scheduling.

The customer reports previously having looked at market solutions such as those supplied by KDO Consulting [4] and Everett Consulting [5], with unsatisfactory results. As such, considering the costs involved for the customer, a tailor-made solution seems to be a good solution.

3.1.2 Algorithms

The problem in question appears to be a constraint satisfaction problem, but also an optimization problem, referring to the requirements for fairness and the junior doctors' appointment to a supervisor. Scheduling problems have been explored for some time as a part of the field of operations research[3]. Reports exist of iterative algorithms designed to solve similar problems [4], and of linear programming[5] being used with success in optimizing nurse scheduling [6]. A similar approach utilizing these findings seems viable.

Operations Research (OR) and Artificial Intelligence[7] have long been seen as alternative, and very different, approaches to solving real world optimization problems, such as scheduling. In OR, the general idea is to reach a high level of efficiency in algorithms, whereas AI prefers a high level of generality, making the algorithms capable of solving a wider range of problems, and also enables the program to consider a wider range of possible solutions. There has been research into combining the best of both worlds [8]. As mentioned in the previous paragraph, this is a constraint satisfaction problem, in the form of shifts that must be filled, a limited number of fillers for these shifts, a limited amount of shifts allowed for each person, and a minimum amount of shifts for each person. Added to this are the constraints on fairness and the desire to have each junior doctor linked with a senior doctor supervisor. It can in other words be considered a constraint satisfaction problem (CSP)[7], with optimization playing a role in considering the value of several possible solutions. Basing ourselves in constraint programming, combining it with OR as necessary [9] should give us much freedom when it comes to defining the problem by ways of constraints, while giving us a large base in the form of algorithms and research from operations planning.

The problem can be considered a job shop scheduling problem[10] (JSSP), where n jobs are to be scheduled on m machines, with a number of constraints. There are n tasks, which must be completed by m individuals, with various constraints on time (one individual can only work constantly for so long) and ability (certain tasks are to be performed by senior doctors, others by junior doctors). The tasks also need to be done in a certain order, with many in parallel, through the week. In our case, two "machines" of different kinds are to be set to each job, with a certain connection between "machines" being preferable. There are algorithms designed to solve JSSPs, and they can probably be tweaked to our needs. The List scheduling

[4] `http://www.kdo.no/`

[5] `http://www.everettsoftware.com/Roster.html`

algorithm by Graham is one of them[11]. The job shop problem is generally NP-Complete[5]. However, by using heuristic algorithms which take advantage of the special properties of this problem, the running time may be improved.

The 0-1 knapsack problem[5] may be considered as a model for the problem, or part of it. The problem is fitting senior and junior doctors with a number of tasks each period, with them only being able to do one task each period, and the junior doctors preferring the same tasks as the doctors. There is a pseudo-polynomial time dynamic algorithm[12] that solves the general 0-1 knapsack problem. However, this does not seem as a particularly useful modeling at the moment, and it may simply be complicating the problem further. The JSSP seems to be a more intuitive fit.

For choosing optimal schedules, as factors such as the connection between the junior doctors and their supervisors for the period may vary between acceptable solutions, linear programming may be used. Linear programming is a technique for optimizing linear equations, subject to various linear inequality and equality constraints. On a standard form, there are several algorithms designed to solve such problems, such as the Simplex algorithm [5], or the ellipsoid method[13].

3.1.3 St. Olavs Hospital IT Systems

There is a strict policy on what kind of software is allowed on the systems at St. Olavs hospital. It is not allowed to run programs which are not previously approved for the system, and installed by the IT department. Hemit[6] is the IT department in charge of the IT systems in St. Olavs. They are responsible for controlling that new programs are necessary, and safe for the systems. This might limit our ability to test the program in the St. Olav system, as there is a processing time before the system can be approved. As the program is not developed yet, it is also problematic to get the unfinished application approved while testing.

Because of this, we plan to set up the database and web server in a separate web hotel account, owned by one of the project members. This is not an acceptable final solution, as the server will require maintenance to be usable — which is beyond the scope of this project. This means that the customer will have to maintain such a server on their own.

3.2 Frameworks Used in the Project

Several frameworks are available in the field of systems development, and are able to reduce development time for several frequently used software solutions. This section introduces those we found to likely be useful to us in this project.

[6] http://www.hemit.no

3.2.1 Software Development Model

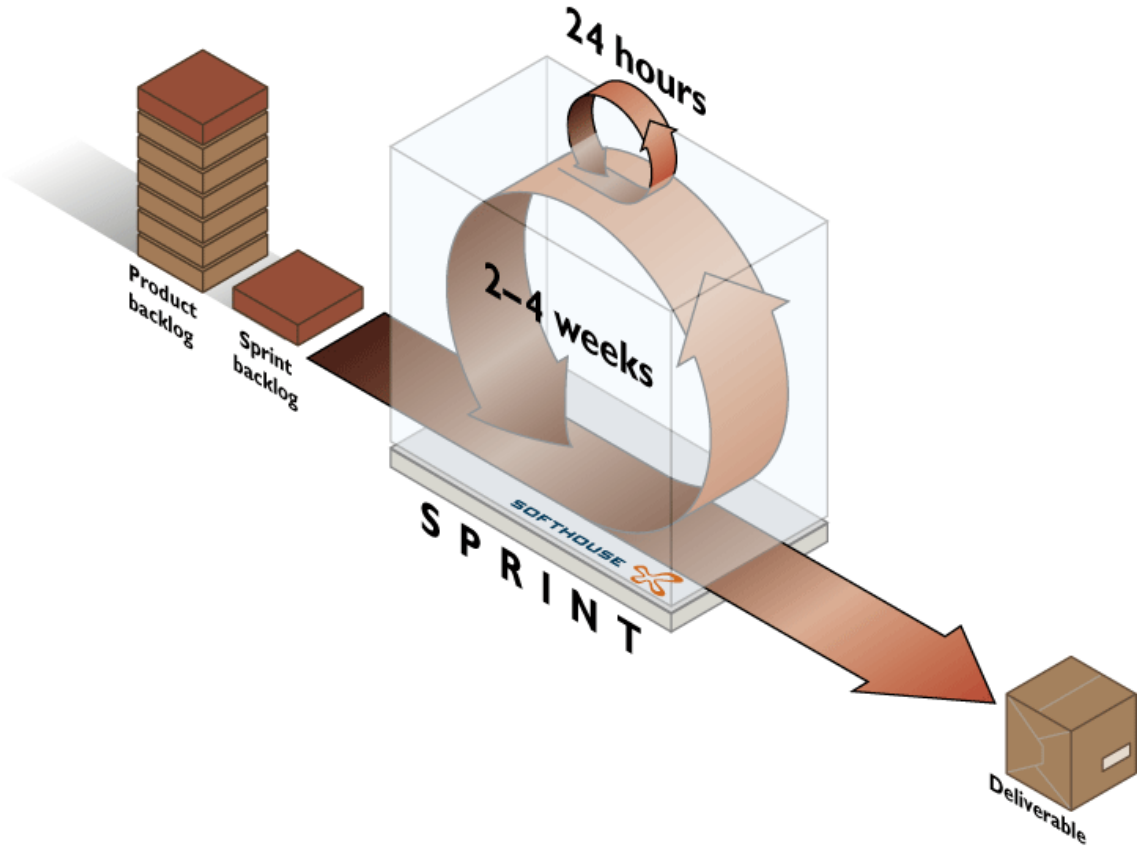

Figure 3.1: The Scrum Process (adopted from Softhouse.se)

Initially there were two development models we considered for this project: the waterfall method and Scrum. Tshe waterfall method is old, but still in use by a lot of companies. With regards to software development however, most agree that the waterfall method is a bad one. The sequential stages simply do not fit software development. The method allows for little flexibility in a business that requires much of it.

Scrum is an iterative and incremental planning and execution method for software development, and is based on the *Agile Manifesto*[14]. With Scrum, one has a series of incremental work periods called Sprints. The sprints in our project last for two weeks each. During a sprint, the team works on the goals set at the beginning of it, at the sprint planning meeting. See Figure 3.1 for a nice illustration of the Scrum method.

The reason why we chose Scrum to be our method, and not the waterfall method, is because Scrum has many advantages for our project. Scrum helps the group members monitor each others work and efforts. If a team member is not doing their part, or needs some help with a task, it is discovered much earlier than what would be the case when using the waterfall method. Frequent inspection of status is also

handy. It makes it easier for us to see how far along we are in the project, and will deliver results early. This way, the customer will have greater insight into our work as well. With a traditional method, it would take longer for the customer to see any working code since the implementation phase is one of the later ones. The customer might also add or change the requirements. With the waterfall method, we would have to do much of the preparation all over again. With Scrum, most of this work is avoided.

3.2.2 Choice of Programming Language

Faced with the decision of programming language to use, our group primarily considered C# and Java.

Our group consists of 5 people who have used Java extensively in their own projects, at university, and some at work. None of the group members have experience with C#.

C# would give us easy drag and drop components for integration with the Microsoft Outlook calendar, which the doctors use, but every group member would need to learn C# to program in it. In Java, we will have to find a way to export our generated schedules in a format that Microsoft Outlook can import, probably iCal. This is very much feasible, as we will not need to implement the whole iCal specification, in fact simple non-recurring events without time zone data will cover our needs, and these can be generated from a template. If more complex events prove necessary, Java libraries are available.

Our group has previous experience using Java frameworks, libraries and database interfaces, which will speed up development tremendously.

We concluded that using Java for this project would yield a higher probability of success, because it would not require us to learn a lot of new language idioms and libraries for very little gain.

3.2.3 Database

Our database needs for this project are connected to our need for a system where every employee can see their own working schedule, without using a specific computer. To make the data accessible from several locations, one easy way is to use a database management system (DBMS). There are several different options, but as our needs for data storage and advanced queries is limited, we do not need to find an "optimal" choice of DBMS. Obvious options are MySQL, PostgreSQL and Apache Derby.

MySQL[7] is a relational database management system, produced by the Swedish company MySQL AB, a subsidiary of Sun Microsystems. It is under GNU General Public License, which means everyone is free to use it, free of charge.

As we mention in Section 3.2.4, we are going to use Hibernate to ease the connection between our class hierarchy and the database. Hibernate supports all the DBMS'es we considered, and does therefore not limit our choice of DBMS.

We chose MySQL because we are already familiar with it, both from school projects and personal projects. We have also observed that it is the most common

[7] `http://www.mysql.com/`

DBMS provided by different web hosting companies, which gives the customer more options when searching for a web host should they decide to deploy Khronos.

3.2.4 Hibernate

We are planning to utilize Hibernate for persistence in this application.

Hibernate is an open source framework[15] for database usage in Java. It greatly simplifies, and to a large extent automates, the often tedious transformation between Java objects and database tables and table relations. It provides solutions for caching, transactions and other features that are not so easy to implement. Hibernate allows the programmer to use plain Java objects with few restrictions.

An interface between Java logic and database tables is generally tedious and time consuming to code, so it makes sense for our group to utilize an already available and user friendly framework, rather than to create our own reimplementation. Hibernate seems to generally garner positive feedback from users compared to other frameworks[16], at least for low data intensity applications[17], which this product is expected to be. Reference material is readily available both on the web and in book stores. Familiarity with Hibernate also appears to be a useful skill to have in the future, career wise.

3.3 Tools Used in the Project

We found several tools intended to aid in various software projects that appeared useful to us. In this section are introductions to the ones we chose to examine further, and tried to utilize.

3.3.1 Trac

Trac[8] is an open source, web-based project management tool. As well as being able to track milestones, tasks and bugs, it has an interface with Subversion as well as a Wiki. Figure 3.2 shows a screen shot of active tickets in an early phase of the project.

We had first planned to use Trac for tracking the Scrum and its backlog, but the Trac installation provided by our department at NTNU has some limitations, making it hard to fit this tool to our development model. Section 3.3.2 describes the tool we will use for tracking the Scrum process.

We will be using the SVN module of Trac, which allows browsing the project files with version history available using a web interface. Also, the Wiki will be used for simple information sharing, such as links to websites for hour registration and a group calendar.

3.3.2 VersionOne: Agile Team Edition

VersionOne[9] is a tool designed for helping teams digitize Scrum artifacts, and to keep track of the project on-line. Figure 3.3 shows part of a screen shot from this

[8] `http://trac.edgewall.org/`

[9] `http://www.versionOne.com`

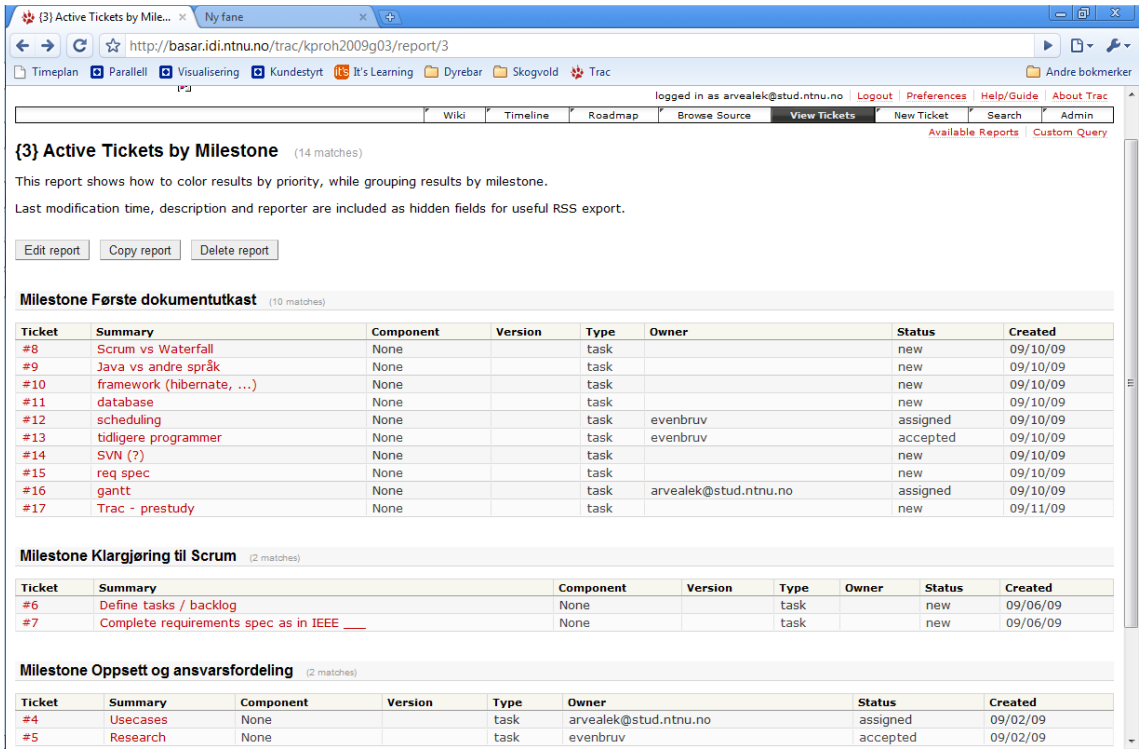
{3} Active Tickets by Mile...
Ny fane
http://basar.idi.ntnu.no/trac/kproh2009g03/report/3
Timeplan
Parallell
Visualisering
Kundestyrt
It's Learning
Dyrebar
Skogvold
Trac
Andre bokmerker
logged in as arvealek@stud.ntnu.no
Logout
Preferences
Help/Guide
About Trac
Wiki
Timeline
Roadmap
Browse Source
View Tickets
New Ticket
Search
Admin
Available Reports
Custom Query
{3} Active Tickets by Milestone
(14 matches)
This report shows how to color results by priority, while grouping results by milestone.
Last modification time, description and reporter are included as hidden fields for useful RSS export.
Edit report
Copy report
Delete report
Milestone Første dokumentutkast
(10 matches)
Ticket Summary Component Version Type Owner Status Created
#8 Scrum vs Waterfall None task new 09/10/09
#9 Java vs andre språk None task new 09/10/09
#10 framework (hibernate, ...) None task new 09/10/09
#11 database None task new 09/10/09
#12 scheduling None task evenbruv assigned 09/10/09
#13 tidligere programmer None task evenbruv accepted 09/10/09
#14 SVN (?) None task new 09/10/09
#15 req spec None task new 09/10/09
#16 gantt None task arvealek@stud.ntnu.no assigned 09/10/09
#17 Trac - prestudy None task new 09/11/09
Milestone Klargjøring til Scrum
(2 matches)
Ticket Summary Component Version Type Owner Status Created
#6 Define tasks / backlog None task new 09/06/09
#7 Complete requirements spec as in IEEE ___ None task new 09/06/09
Milestone Oppsett og ansvarsfordeling
(2 matches)
Ticket Summary Component Version Type Owner Status Created
#4 Usecases None task arvealek@stud.ntnu.no assigned 09/02/09
#5 Research None task evenbruv accepted 09/02/09

Figure 3.2: Screenshot of Trac

service, with a part of the storyboard during sprint 4.

Some say that such tools can be a bad idea, as it makes the group adapt the process to the tool, and not the other way around. This was discussed, and we found out that the benefits of using the tool are larger. As we do not have an assigned office, we do not have our own white board to track the Scrum process. We could of course have used a wall in one of the rooms in the P15 building, but we risk that the room is taken when we need to hold Scrum meetings, as well as "funny" people moving tasks around randomly. Another clear benefit is, as this is on-line, everyone has access to it from wherever they are. Because we are taking different classes, it is often hard to work together all day. By tracking the progress on-line, everyone will be able to see who is doing what.

This is a commercial product, with license requirements. They do, however, provide a 1-year free account for groups up to 10 persons. This enables us to use this tool without any extra costs, except for the time spent to learn it.

3.3.3 Apache Tomcat

As the program is being implemented as a web application, and we want to develop using Java, we need an application server / servlet container. There are several open-source solutions available to suit our needs: *Apache Tomcat*, *GlassFish* and *Jetty* are three options. They are all free to use. A list of servlet containers are described in [18]

Some of the group members have used Apache Tomcat before, and this is why we chose to use Tomcat. When developing web-applications in Java, the way to do

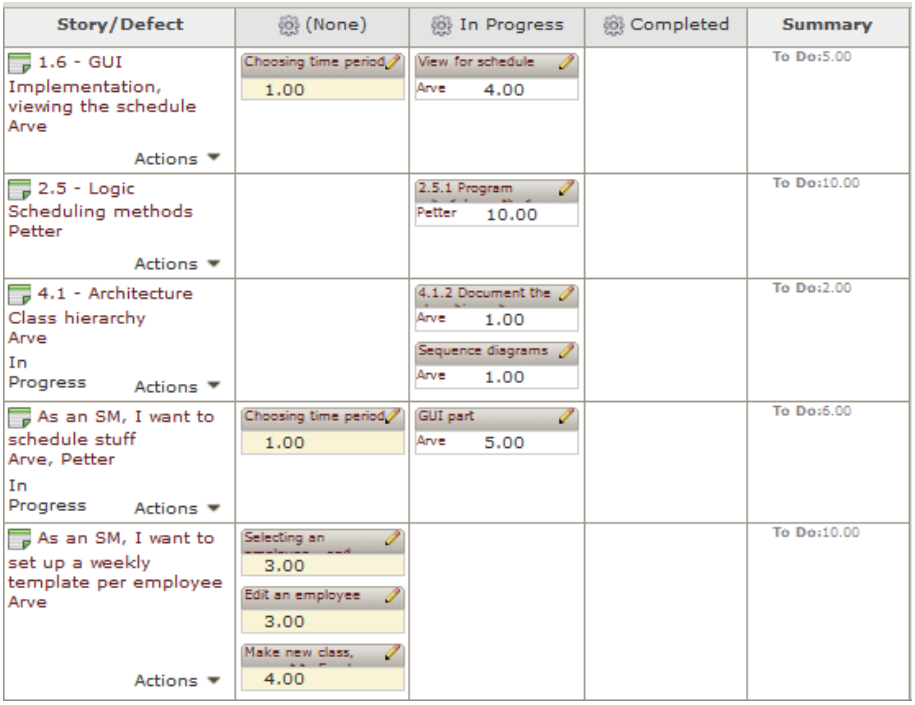

Figure 3.3: Screenshot from VersionOne: A part of the storyboard

it is the same between the different servers. This means it should not be a problem if we choose to change the server — we will only have to set up the configuration again, and most of the code will stay unchanged.

3.3.4 Balsamiq Mockups

Designing the graphical user interface (GUI) is an important process and needs careful consideration. One way of making the process easier is by using a mockup tool. A mockup is usually a scale model of a design used for demonstration, teaching or evaluation of the design. There are many mockup tools available on-line and free to use. Using such a tool is a nice way to illustrate early thoughts on the GUI. It is much easier to make changes digitally than drawing on a piece of paper. With a mockup tool, the different images also get much more consistent.

The flagship product of Balsamiq Studios is their mockup tool. It can be used free in a browser, and it exports the mockup as a XML text so it can be imported again on your next work period. It is easy to use, it is understandable, and it has the necessary tools and images we need for our project. Those are the main reasons why we have chosen this tool to work with.

3.3.5 Integrated Development Environment (IDE)

For writing Java, there exist several different IDE's. *Eclipse*, *NetBeans* and *IntelliJ IDEA* are the three most used ones. While Eclipse and NetBeans are open source and free to use, IntelliJ IDEA is proprietary. As we have no economy for buying licenses for different software, IntelliJ IDEA is not considered an option.

NetBeans is developed by Sun Microsystems, and is offered as a bundle when

downloading the Java SDK from Sun. It supports different aspects of Java development, with built-in support for Subversion, Hibernate, Swing and other relevant technologies. It also has a convenient plugin for drawing UML diagrams. NetBeans could provide a great tool for our development, as we are to use these technologies.

Eclipse is the programming tool we have been encouraged to use from the start in NTNU, and therefore also the one we are most familiar with. It supplies a vast range of plugins for different purposes - for example Subversion, Hibernate and Swing. This means that if we set up Eclipse in a proper way, it will be able to serve our needs.

We have chosen to use Eclipse as the main IDE, with support from some NetBeans plugins. The developers are, however, free to use whichever tool they find suited for their needs.

CHAPTER 4

Requirement Specification

The requirement specification chapter gives a detailed description of all the requirements which must be fulfilled for the program to behave according to the wishes of the customer. The chapter structure is based on the IEEE recommended practice for software requirements specification[19]. It includes an introduction, an overall description and both visual and textual use cases, which show how the user will interact with the program. Use cases are also mapped to functional requirements. We also include a section with non-functional requirements, which describe other aspects of the program.

We considered gathering the requirements for this project to be of vital importance, as well as highly challenging. Misunderstanding or overlooking requirements could result in a pointless or unusable product. This project came about as the result of a perceived need from the customer, and a project that failed to attend to that need, no matter how elegantly packaged or user friendly, would be a failed project.

4.1 Foundation

This section contains a basic introduction to the requirement specification itself, as well as the general structure of the requirements.

4.1.1 Purpose

The purpose of the requirement specification is to get a clear view of the requirements of the program. It is important for the group to have a requirement specification which is easy to read and understandable, and at the same time containing all the requirements gathered for the group to get a better overview. This chapter will be referred to again and again during implementation.

Obvious users of this specification are the customers at St. Olav and the project group. Other users include the teaching supervisors and future users of the system.

4.1.2 Scope

The system is intended to make a flexible schedule for senior and junior doctors, and the tasks they need to cover, which have to be distributed according to several rules. The distribution must also be done fairly, it has to sum up the same working

hours for all employees. If a task does not have a doctor assigned to it, or if it has more than one, the system must notify the user.

The program does not need to handle unplanned absence of doctors, sickness or similar. This will be handled by the customer manually. There is almost never a problem of another doctor not picking up the tasks that become unassigned. The system will, however, notify the user about the unassigned task.

4.1.3 Overview

The rest of this chapter consists of an overall description of the product and the requirements themselves. In the overall description we describe some aspects of the product, for example defining the users. In the requirements section we list the functional and non-functional requirements, along with use case diagrams and textual use cases.

The sections are organized as follows:

4.2 Overall description

4.2.1 Product perspective

4.2.1 User interface

4.2.2 Product functions

4.2.3 User characteristics

4.2.4 Constraints

4.3 Specific requirements

4.3.1 Functional requirements

4.3.2 Non-functional requirements

4.3.3 Use cases

4.2 Overall Description

This section contains high level requirements, including requirements for the system on which the system is to be run.

4.2.1 Product Perspective

The product is not supposed to communicate or cooperate with any existing systems, except for being able to export data to iCal format, which makes it possible to import data into calendar software, like MS Outlook. This means the product is completely self contained.

The iCal format is described in RFC2445 [20].

User Interface

The user will operate the system using a computer running Windows XP or newer — with screen, mouse and keyboard. The system will require a screen resolution above 800x600 pixels.

The system will have two interfaces:

- The planning interface, which will have one user at a time. This is the part where scheduling variables are set up, and changes to the schedule can be made.
- The overview interface, which will have n users at a time, where the user can see the schedule, but not do any changes.

The user interface language shall be in Norwegian, as this is required for software used in Norwegian hospitals.

4.2.2 Product Functions

The system shall be able to set up a valid schedule for working hours in the hospital, given constraints input by the user. When this schedule is ready, users accessing the overview interface should be able to see the given schedule.

4.2.3 User Characteristics

The different users of the system are doctors and secretaries, or any other employee in the schedule.

Hospital employees have to use several different computer systems every day, and are not necessarily interested in learning yet another one. This increases the need for a user friendly and intuitive user interface.

There are two defined user categories:

- Schedule master: This user will have access to the scheduling interface. He will set the constraints, and generate the plans. This could be any employee, but the role will be fixed.
- Employee: This is everyone else. They will only have access to show and print the finished plans.

4.2.4 Constraints

- The user interface has to be presented in Norwegian, according to rules for software in Norwegian hospitals.
- The project has a finite deadline at November 19, 2009.
- The project group has five members with varying experience with developing software. There will not be any more resources allocated.

4.3 Specific Requirements

This section contains the specific requirements for the system, both functional and non functional, as well as use cases corresponding to the functional requirements.

4.3.1 Functional Requirements

ID	Description	Priority
F01	The user can define a plan.	High
F02	The user can make changes in a generated plan.	High
F03	The user can attach two doctors for a given period.	Medium
F04	The user can define a doctor in the system.	High
F05	The user can set availability for a doctor for a period of time.	Low
F06	The user can define rooms/departments.	High
F07	The user can define tasks.	High
F08	The user can assign a doctor to a fixed task.	Medium
F09	The user can choose to view the plan for everyone or just himself.	Medium
F10	The user can choose to view the plan for different time scopes; day, week, month, etc.	Medium
F11	The user can print the schedule.	High
F12	The user can log in.	High
F13	The user can log out.	High
Optional		
F14	The user should be able to export data to the iCal format.	Low

Table 4.1: Functional requirements

4.3.2 Non-functional Requirements

ID	Description	Priority
NF01	There must exist a friendly user manual and a proper documentation of the system design.	High
NF02	The schedule must be set up within reasonable time after specifying all constraints.	Low
NF03	It should be easy for the user to insert correct input.	Medium
NF04	The application must be simple and easy to understand.	High
NF05	The program should allow undo actions.	Low
NF06	The program must not require external components under proprietary licenses.	High
NF07	The application must distribute the "on-call"-hours fairly, depending on the working hours.	High
NF08	The application must make sure that all the tasks of the week are covered and notify the user if there is a task that has not been covered or if a employee is double booked.	High
NF09	The application should display a schedule in a printable format.	High
NF010	The application must discern between the different working hours of the specialists and the rest.	High
NF11	The application must be able to discern between the different tasks, as some must be done several times a week while some only once a week.	High

Table 4.2: Non-functional requirements

4.3.3 Use Cases

Figures 4.1 to 4.3 show use case diagrams used in the process of writing the textual use cases.

Tables 4.3 to 4.10 show the textual version of these use cases.

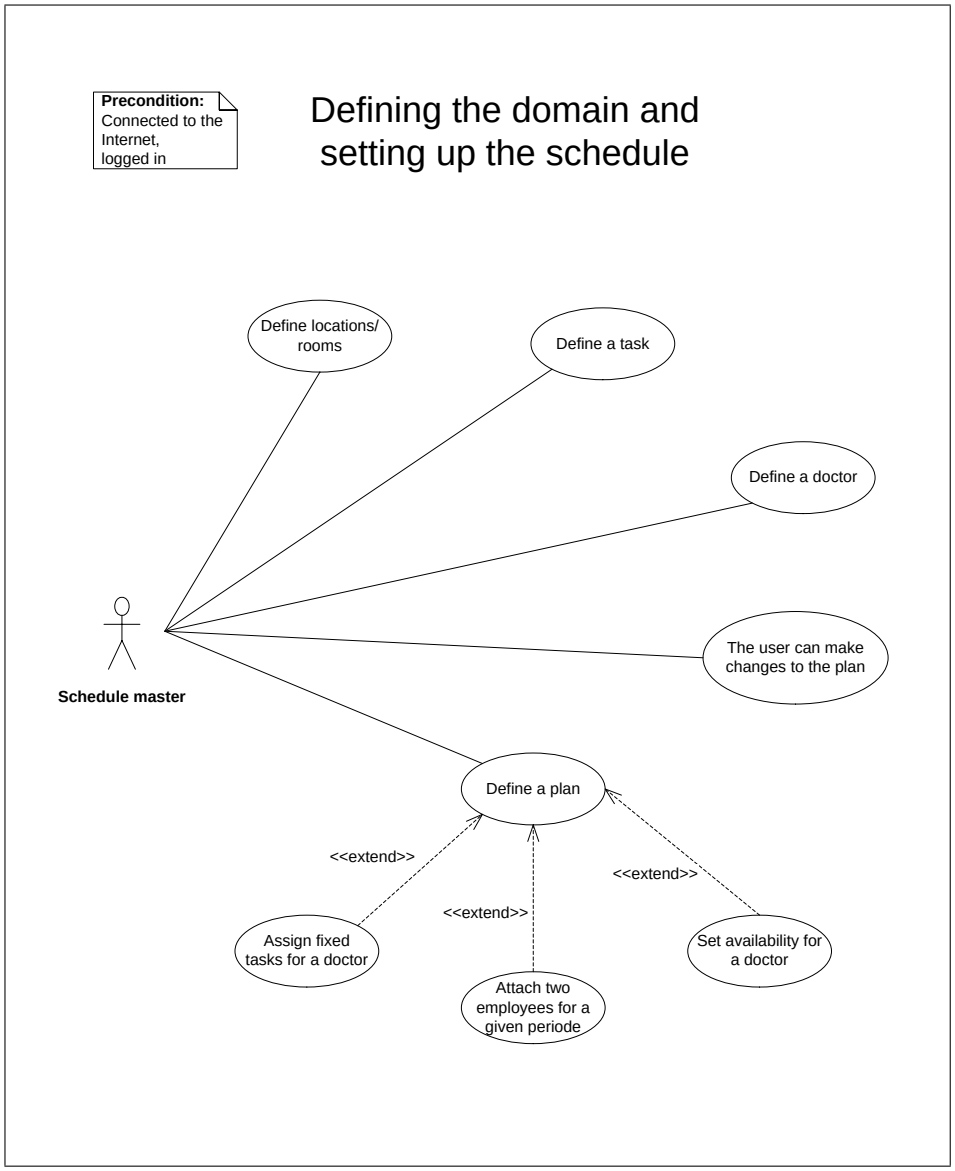

Figure 4.1: Defining the domain

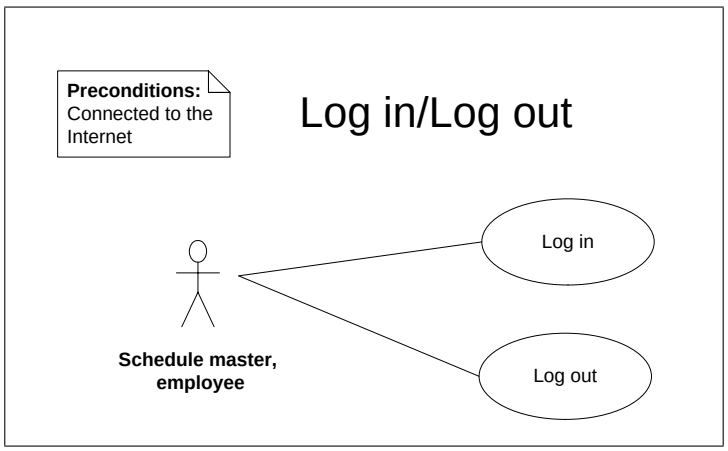

Figure 4.2: Logging in and out

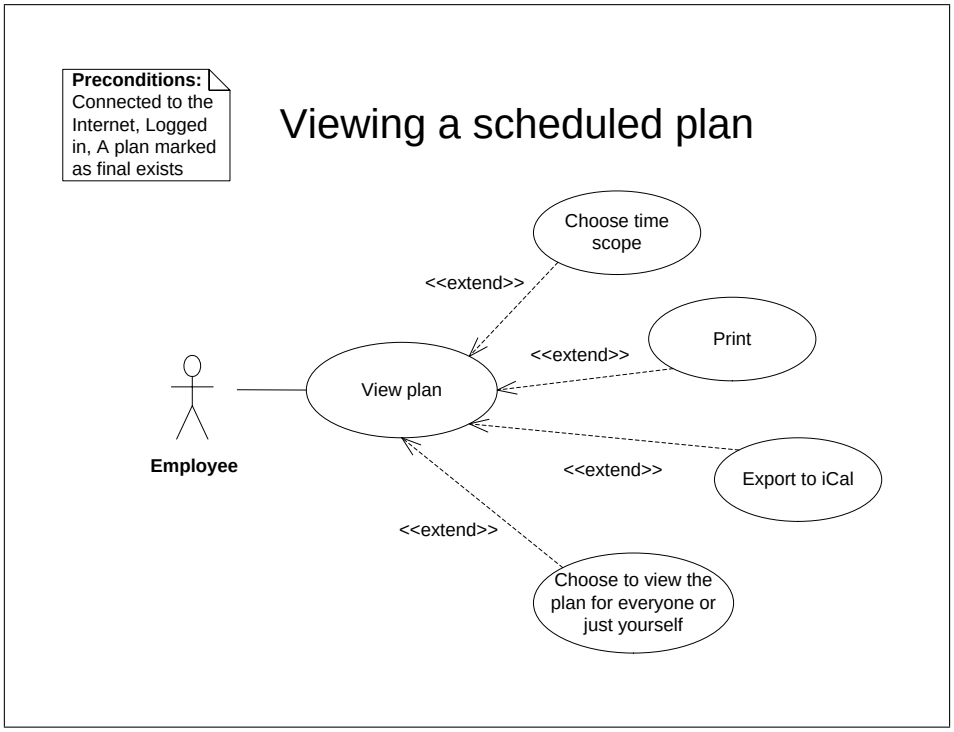

Figure 4.3: Viewing a scheduled plan

Use case name: Logging in
Precondition: User is connected to the Internet
Participating actors: Schedule master, employee

Steps	Action	Expected response
1.	User goes to the Khronos page	The Log in screen is displayed
2.	The user enters user name and password, and pushes the log in button	The front page is displayed

Exceptions

Steps	Problem	Solution
1.1	The user is not connected to the Internet	Contact hospital system admin
1.2	The server is down	Contact Khronos system admin
2.1	The user enters wrong user name and/or password	Contact Khronos system admin to retrieve the user name and/or password

Table 4.3: Textual use case: Logging in

Use case name: Logging out
Precondition: User is logged in to the system
Participating actors: Schedule master, employee

Steps	Action	Expected response
1.	User chooses to log out	The log in screen is displayed, the user is no longer logged in

Exceptions

Steps	Problem	Solution
1.1	The user has lost the Internet connection	There is a time out, so you will automatically be logged out

Table 4.4: Textual use case: Logging out

Use case name: Define a department
Precondition: The user is logged in as schedule master
Participating actors: Schedule master

Steps	Action	Expected response
1.	The user chooses to define a department	The system displays the list of existing departments
2.	The user chooses if he wants to edit, remove or add a department	The system displays the page for edit, remove or add a department
3.	The user chooses to remove a department	The system displays the remove department page, with a confirmation dialog, go to 6
4.	The user chooses to edit a department	The system displays the edit department page, go to 7
5.	The user chooses to add a department	The system displays the add a department page, go to 8
6.	The user chooses yes or no	If yes, the department will be removed from the system. If no, the action is aborted and the previous page is displayed
7.	The user makes the changes he wants and chooses to save changes	The system is updated with the new changes and the previous page is displayed with the new changes in the list
8.	The user writes the name of the department he want to add to the system and saves it to the system	The new department is saved in the system, and the previous page is displayed with the new department in the list

Exceptions

Steps	Problem	Solution
4.1	The user chooses to edit a department to the same name as an existing department	Department names are unique, so this will not be allowed by the system, the previous page is displayed
5.1	The user chooses to add a department with the same name as an existing department	Department names are unique, so this will not be allowed by the system, the previous page is displayed

Table 4.5: Textual use case: Define a department

Use case name: Define a task
Precondition: The user is logged in as schedule master
Participating actors: Schedule master

Steps	Action	Expected response
1.	The user chooses to define a task	The system displays the list of existing tasks
2.	The user chooses if he wants to edit, remove or add a task	The system displays the page for edit, remove or add a task
3.	The user chooses to remove a task	The system displays the remove task page, with a confirmation dialog, go to 6
4.	The user chooses to edit a task	The system displays the edit task page, go to 7
5.	The user chooses to add a task	The system displays the add a task page, go to 8
6.	The user chooses yes or no	If yes, the task will be removed from the system. If no, the action is aborted and the previous page is displayed
7.	The user makes the changes he wants and chooses to save changes	The system is updated with the new changes, and the previous page is displayed with the new changes in the list
8.	The user writes the name of the task he wants to add to the system, and saves it	The new task is saved in the system, and the previous page is displayed with the new task in the list

Exceptions

Steps	Problem	Solution
4.1	The user chooses to edit a task to the same name as an existing task	task names are unique, so this will not be allowed by the system, the previous page is displayed
5.1	The user chooses to add a task with the same name as an existing task	task names are unique, so this will not be allowed by the system, the previous page is displayed

Table 4.6: Textual use case: Define a task

Use case name: Define an employee
Precondition: The user is logged in as schedule master
Participating actors: Schedule master

Steps	Action	Expected response
1.	The user chooses to define an employee	The system displays the list of existing employees
2.	The user chooses if he wants to edit, remove or add an employee	The system displays the page for edit, remove or add an employee
3.	The user chooses to remove an employee	The system displays the remove employee page, with a confirmation dialog, go to 6
4.	The user chooses to edit an employee	The system displays the edit employee page, go to 7
5.	The user chooses to add an employee	The system displays the add an employee page, go to 8
6.	The user chooses yes or no	If yes, the employee will be removed from the system. If no, the action is aborted and the previous page is displayed
7.	The user makes the changes he wants, and chooses to save changes	The system is updated with the new changes and the previous page is displayed with the new changes in the list
8.	The user writes the name of the employee he wants to add to the system, and saves	The new employee is saved in the system, and the previous page is displayed with the new employee in the list

Exceptions

Steps	Problem	Solution
4.1	The user chooses to edit an employee to the have the same initials as an existing employee	Employee initials are unique, so this will not be allowed by the system. The previous page is displayed
5.1	The user chooses to add an employee with the same initials as an existing employee	Employee initials are unique, so this will not be allowed by the system. The previous page is displayed

Table 4.7: Textual use case: Define an employee

Use case name: Define a plan
Precondition: The user is logged in as schedule master
Participating actors: Schedule master

Steps	Action	Expected response
1.	The user chooses to define a new plan	The system displays the define plan page
2.	The user chooses time period to make the plan for and makes other optional specifications for the plan, go to 8	The system displays the changes that the user makes
3.	The user sets availability for an employee	The system marks the changes made in the plan, go to 8
4.	The user chooses to attach two employees, go to 6	The system displays the attach two employees page
5.	The user chooses to assign fixed tasks to an employee, go to 7	The system displays the fixed tasks for an employee page
6.	The user chooses which employees to attach, time period, and saves the changes, go to 8	The system marks them as attached in the plan and displays the previous page
7.	The user chooses which employee to assign fixed tasks to, which fixed tasks the employees should have, and saves the changes	The system marks the fixed tasks in the plan and displays the previous page
8.	The user marks the plan as final	The plan is marked as final and is available for viewing.

Exceptions

Steps	Problem	Solution
3.1	The user sets availability for an employee and this results in under-booking of a task	The system will notify the user about under-bookings
4.1	By attaching two employees a task is left under-booked or a doctor gets double-booked	The system will notify the user about under-bookings and double-bookings
5.1	A doctor gets double-booked	The system will notify the user about double-bookings

Table 4.8: Textual use case: Define a plan

Use case name: Make changes to the plan
Precondition: The user is logged in as schedule master
Participating actors: Schedule master

Steps	Action	Expected response
1.	The user chooses, make changes to plan	The system displays the change plan page
2.	The user make the changes he wants	The system notifies the user if there are any problems with the new changes
3.	The user marks the new plan as final	The system notifies the user that the plan is marked as final

Exceptions

Steps	Problem	Solution
2.1	The user makes a change to the plan, which results in double-booking of a doctor or under-booking of a task	The system handles this by notifying the user so that the user can correct this

Table 4.9: Textual use case: Make changes to the plan

Use case name: View plan
Precondition: Logged in as schedule master/employee, a plan is marked as final
Participating actors: Schedule master, employee

Steps	Action	Expected response
1.	The user chooses to view the plan	The system displays the plan for a default time scope for every employee
2.	The user chooses to changes the time scope	The system displays the plan for the specified time scope
3.	The user chooses to view the plan for just himself	The system displays the plan for a default or specified time scope for the employee logged in
4.	The user chooses to print the plan	The system prints the plan
5.	The user chooses to export to iCal	The system exports to iCal

Exceptions

Steps	Problem	Solution
1.1	A plan is not marked as final	Contact the schedule master
2.1	A plan is not marked as final for the specified time scope	Contact the schedule master
4.1	There is a problem with the printer	Contact the Hospital system admin

Table 4.10: Textual use case: View plan

4.3.4 Testing

A test regime was designed at this point, to ensure that the final product would be up to specifications. It was decided to perform unit testing on the code as it was created during the various sprints. Integration tests were to be performed by the coders as the different parts were integrated. As the sprints would not be planned in detail until closer to them starting, exact test plans could not be created at this point. One exception was the system test plan, intended to be run at the end of the fourth sprint.

A system test plan was created, reflecting the system requirements. The tests were designed to run at the end of the implementation process to test for bugs and faults, as well as to verify the completion of the program, in accordance with the requirements. A total of eleven tests were written, covering one or more functional requirements, and in total covering all the non-optional functional requirements. The plan can be found in Appendix E. The test procedures were deliberately vaguely worded on the exact actions to be performed, as we at the point of requirement specification had limited knowlege of the final form of the system.

CHAPTER 5

Sprint 1

This was the first sprint of the project. There were several tasks we chose to be part of it, mainly making a graphical user interface example and implementing the basics in architecture and logic.

5.1 Planning

The start of a project is very important. What we did in this sprint would lay out the foundation on which we could continue the work in later sprints. We had to make sure that we put what we found in the preliminary studies to good use, and worked hard so both the customer and ourselves would be satisfied with the progress.

5.1.1 Goals

The goal of this sprint was to have an initial draft for the graphical user interface ready. We wanted to have it ready to show the customer in our next meeting to get valuable input and comments. We also aimed to have some important foundations of the program implemented at the end of the sprint. More trivial goals were also to have the name and logo for the project made.

5.1.2 Sprint Backlog

ID	Priority	Description	Req.	Hours est.	Hours used	Responsible
2.1	High	Make the object model shell	F01	6	6	Petter
2.2	High	Add methods to model classes	F01	2	2	Petter
2.3	High	Develop the object model methods	F01	8	8	Petter
2.4	High	Create scheduling class and methods	F01	2	2	Petter
3.1	High	Set up database	F13	1	1	Arve
3.2	High	Set up and test Hibernate	F13	8	8	Arve
4.1	High	Define the class hierarchy	None	8	8	Arve
1.1	Medium	Make GUI mockups	NF04	2	4	Thorbjørn
1.2	Medium	Research advantages and disadvantages of choices in GUI	NF04	4	4	Thorbjørn
5.1	Medium	First draft of report	None	34	40	Petter
6.1	Low	Testing of scheduling, persistence and database	NF02	1	3	Thorbjørn
5.2	Low	Make the logo for the project	None	2	2	Susanne
5.3	Low	Name the project	None	2	2	Susanne
			Sum:	80	88	

Table 5.1: Sprint 1 Backlog

5.2 Design

By using *Balsamiq Mockups*, we made a draft of what the graphical user interface (GUI) would possibly look like, though changes were expected to be made before the completion of the project. It was made for the customer to get an idea of the interface which contained most of the functionalities we would implement. In our next customer meeting we would show it to them and explain what our thoughts were. Any feedback from the customer would be very valuable for us to continue the process. Figure 5.1 shows a screenshot of the mockups tool.

There were some important things we needed to consider with the design of the GUI. The usability aspect was obviously one of them. The definition of usability according to ISO 9241-11[21] is: "the effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments".

The ISO 9241 also specifies: "Effectiveness measures the accuracy and completeness with which users achieve specified goals. Efficiency measures the resources expended in relation to the accuracy and completeness with which users achieve goals. Satisfaction measures the freedom from discomfort, and positive attitudes towards the use of the product."

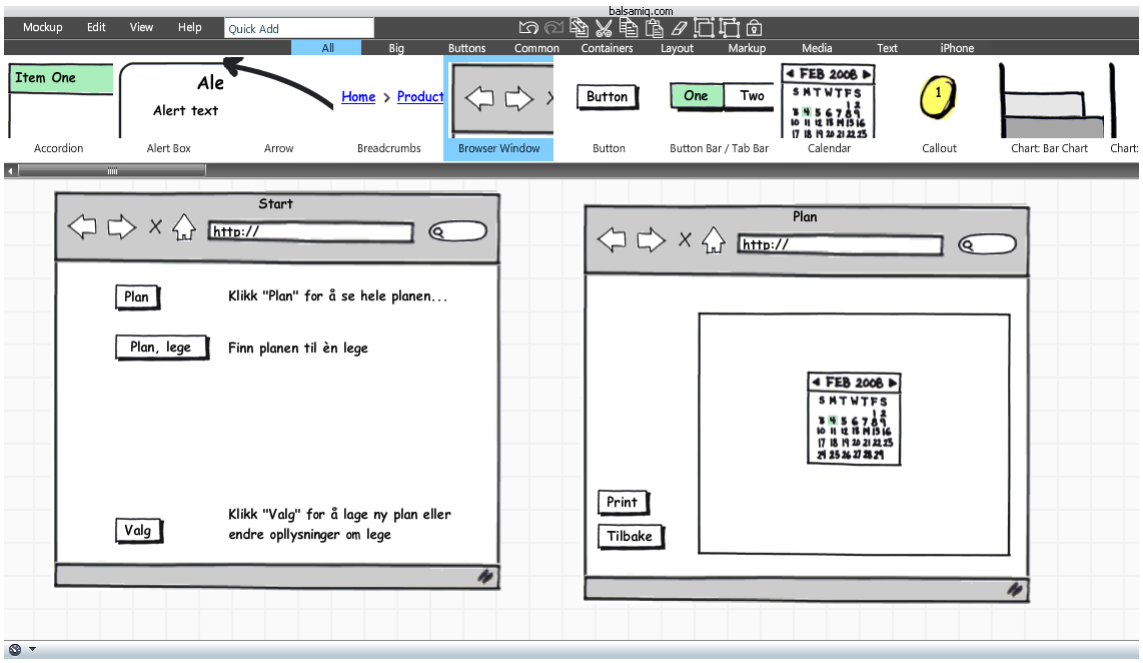

Figure 5.1: Screenshot of Balsamiq Mockups

So the effectiveness, efficiency and satisfaction are measurable. The GUI of our program was to be rather simple, and the tasks done by the user not very extensive, but we still planned to do some measurements.

Since the final product would take the shape of a web application, we reasoned that the GUI would probably consist of simple tables, text fields and buttons. Objects that may distract the user from doing his or her task properly and efficiently, was to be kept to a minimum.

Even though we did not plan to have many different screens for the user to view, in terms of navigation there were some things that needed to be emphasized. A page must always let the user know where he/she is. The page must be clear enough about its content so the user does not have to about the purpose of it. It should also be clear where the user might navigate to from this page, and where the user came from.

These were goals we tried our best to fulfill, and always kept in the back of our minds when designing and implementing the GUI.

5.3 Name and Logo

When we started work on sprint 1, we thought that we should have a name for the project. A name with relevance, but shorter and more catchy than the working title, "Flexible Duty Roster for Doctors in Hospitals", was desired. The name Khronos was brainstormed during this sprint, and a logo was designed to reflect this name.

The logo was made after the project name, and a representation of time and health was sought. Chronos was often represented by an old and wise man, but we wanted our own interpretation. We wanted something that looked like it belonged

at a hospital, combined with a time element.

5.4 Implementation

We focused on setting up the skeleton for the program. The different classes representing the domain were specified, some relations between these, and their constraints. The skeleton of the scheduling algorithm was made, but there was still a lot of work to be done.

We implemented the basic logic of the program, using the Java Swing Framework. This, however, proved useless, due to our last-minute changes in architecture. For new computer programs to be allowed within the hospital environment, the software had to be verified by the IT department. This could take a long time and could not be done until the software was in its final form. Because of the time limit, we wanted the customer to be able to use the program as soon as possible. Because of this, it was decided to make the program a web application in Java. This was to allow it to run on a server, without the limitations of the internal hospital rules.

5.4.1 Class Diagrams

At this point in time, the scheduling algorithm was not yet final. As such, the domain model was still subject to changes. If we saw that we needed changes to suit the scheduling algorithm, they would be reflected in the domain model. Therefore, the class diagram in this chapter is lacking some details. Figure 5.2 shows the package overview, and Figure 5.3 shows a more detailed view of the package *model*.

5.4.2 Packages

To keep the code organized, we split it into packages, which we thought were logically separate. *Model* contained the domain model, *persistence* contained the classes related to the database (via Hibernate), and *scheduler* contained classes used for scheduling. As we made this, we had in mind that more packages could be added later, as the web interface was planned to be defined in the next sprint.

5.4.3 Model

As shown in Figure 5.3, the domain consisted of `Employee`s who work in a `Department`. A `Task` is performed by a `Position`, and a `Task` belongs to a `Department`. By adding more information in the next sprint, the final result would be mapping the `Employee`s to solve the different `Task`s.

A Position in our domain was either a senior or junior doctor. From an object oriented standpoint, it might seem strange not to make two subclasses `SeniorDoctor` and `JuniorDoctor` inheriting the `Employee`-class. We, however, made it this way, so that other departments, with other needs, may define a series of different employees. In that way, Khronos could be able to schedule other domains than the medical one as well. This was not a goal, but a possible bonus.

The task had some more attributes than shown in the class diagram. They were omitted to make the diagram less cluttered. It was set to be performed on a series

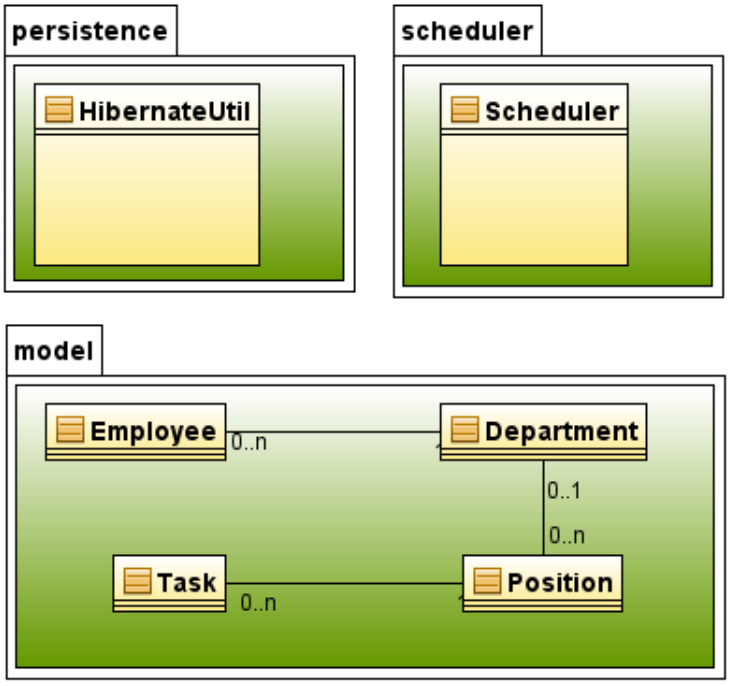

Figure 5.2: Class diagram: Package overview

of weekdays (one boolean per week day), starting at a given time, and with a given duration. In addition, one could define a duration before and after the task, where the employee performing the task is not assigned to other tasks. More detail to be added in the next sprint.

5.4.4 Database Mapping

As Hibernate defines schema for the database based on annotations in the provided classes, we do not provide an ER-diagram. The relations in the class diagram show the same mapping between classes, where the classes correspond to entities/tables.

5.5 Testing

We did not have any formal testing in this sprint since not much more than basic functionality was implemented, but we did perform different tests parallel with coding to ensure the coding so far behaved as expected.

5.5.1 Scheduling

In this sprint, we met with the customer to gather information about how the scheduling is being done today, and what rules they are currently following, either explicitly, or following anyway even though they may be unwritten. We created a prototype to test the rules we gathered from the customer, and checked the output

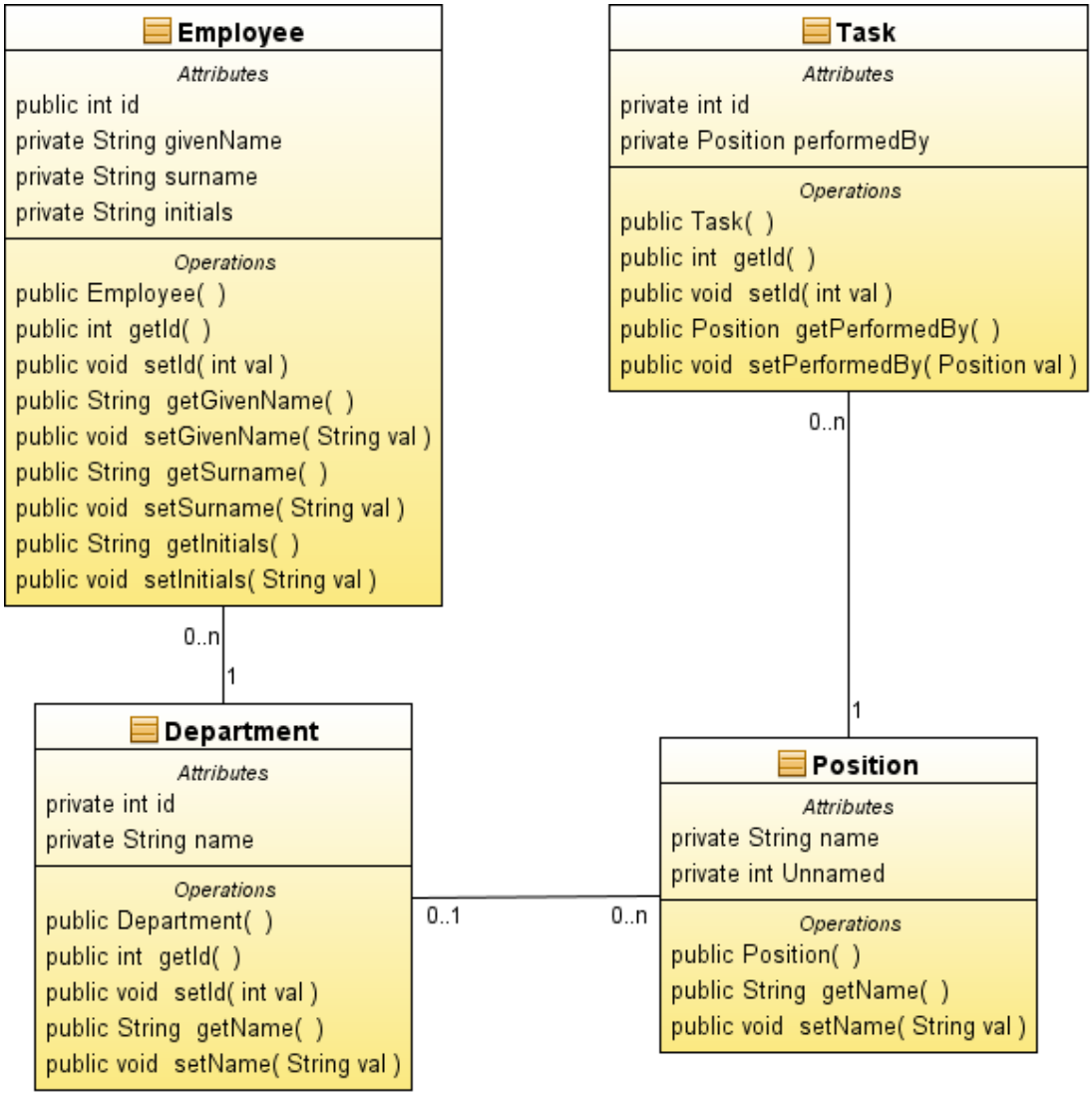

Figure 5.3: Class diagram: A closer look on the *model* package.

to see if it was sensible, or if we needed more details. We decided we needed more input from the customer and planned to gather that during the next sprint.

5.5.2 Persistence and Database

As Hibernate and the database were set up, we had to test that the relations were working as intended. This was done by adding new entities, fetching them, editing them, and persisting them again. The testing was not done formally, as the structure of the model was not yet complete. The testing showed some minor faults that were corrected underway.

5.6 Evaluation

In this section we show the burn down chart, and discuss how the work progressed and how sprint process itself evolved.

5.6.1 Review Meeting

Only the team members were present at this sprint's review meeting. There was nothing to demonstrate at this early stage, but everybody explained the work they had done in more detail than on the daily scrums. In plenum we discussed each others work and the whole work progress. All this set the basis for the next sprints planning meeting.

5.6.2 Burn Down Chart

Figure 5.4 shows the burn down chart for the first sprint. It shows that our estimates were not perfect, but not that far off. All in all, the team members agreed we did a good job on the estimates and sticking to the plan.

5.6.3 Work Progress

We did some research on the design, we implemented the skeleton of the program including some basic methods and we did not deviate from the plan too much. There were no problems we were not able to overcome, although it was a bit more time consuming than we had planned.

We were positive that in the next sprint we would get much of the implementation done. We would have a customer meeting at the end of the sprint where we would present the work and show them many of the functions that was planned for the final version.

We gathered requirements for the scheduling algorithm and implemented a prototype in order to compare our understanding to customer expectations.

5.6.4 Retrospective

In the retrospective meeting we agreed on a few things we needed to do better in the next sprint. We had a few problems with VersionOne, and we needed to get

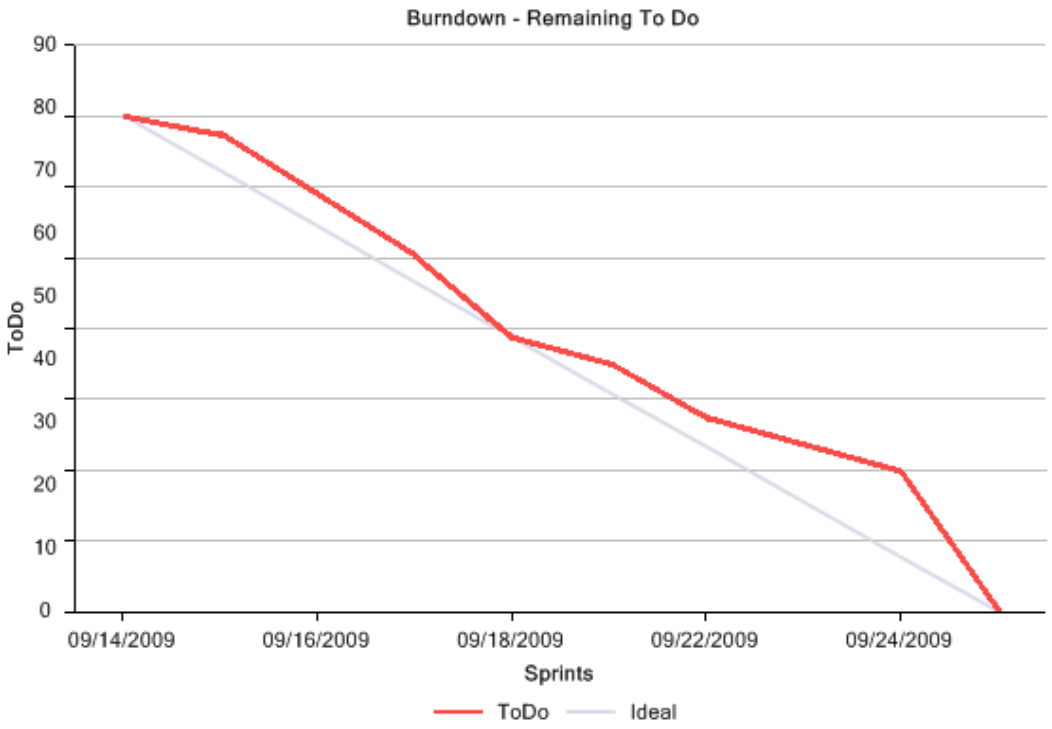

Figure 5.4: Burn down chart

more familiar with this program. There was some confusion about how to register tasks, and how to keep track of the progress and work hours. This resulted among other things in a very poor burn down chart, since we added and removed tasks, and registered work hours in the wrong place. We therefore handled tracking the first sprint manually, and also made the burn down chart ourselves. Unfamiliarity with different tools is one of the risks we anticipated in the risk analysis. Fortunately VersionOne was not critical for the development itself, only the tracking. For the second sprint we were now better prepared.

There were also some positive experiences we need to point out. This was the first time any of the group members were using Scrum, but all were impressed and gained good insight into this method of development. Since Scrum is getting more and more recognition out in the professional world, this experience may prove to be valuable indeed.

CHAPTER 6

Sprint 2

In the second sprint we decided to focus heavily on the implementation of the program. Much of the basic foundations of the implementation was done in sprint 1, and in this sprint we expanded it greatly.

6.1 Planning

We planned to involve the customer more, now that the implementation was under way. It was imperative that the scheduling algorithm was according to the customers wishes, or else the resulting program would be unusable. We also planned to not put much thought into the design of the graphical user interface in this sprint, and rather focused on getting parts of the program up and running. We did perform a customer meeting where we discussed the graphical user interface, but focused mostly on the functions and not the presentation.

6.1.1 Goals

We aimed to have the graphical user interface functions, and also many functions connected to scheduling, ready to show the customer at the end of this sprint.

6.1.2 Sprint Backlog

ID	Priority	Description	Req.	Hours est.	Hours used	Responsible
1.3	High	Make basic layout for the web page	NF04	4	6	Susanne
1.4	High	Make table for data input	NF03	5	8	Arve
1.5	High	Initial usability test with customer	NF04	5	5	Thorbjørn
2.5	High	Expand the object model shell (domain)	F01	2	6	Arve
2.6	High	Extend the object model methods	F01	2	3	Arve
2.7	High	Expand the scheduler class	F01	18	31	Petter
4.2	High	Set up the class hierarchy	None	18	22	Arve
4.3	High	Set up Tomcat	None	8	14	Arve
1.6	Medium	Web page layout documentation	NF03	6	8	Thorbjørn
6.1	Low	Scheduling testing	F01	4	2	Petter
6.2	Low	Object model testing	F01	4	2	Petter
4.4	Low	Class hierarchy documentation (UML)	None	5	5	Arve
			Sum:	81	112	

Table 6.1: Sprint 2 Backlog

6.2 Implementation

In this phase, we set up the web application environment, and made a working example. A screenshot can be seen in Figure 6.1. The package collection was extended a bit, and the updated diagram is shown in Figure 6.2.

6.2.1 Scheduling

At this stage we expanded upon the prototype we made in the previous stage as we gathered more scheduling rules and examples from the customer. We started moving the scheduling into the main code base, and adjusted the model classes in order to achieve this integration.

At this point the planner was able to make plans that obeyed the consecutive working hour limits given in the Norwegian work environment regulations. In addition, some tasks at the hospital have requirements for rest before and after the task. Functionality was added to allow the user to input this information and to have the planner take it into account.

The planning algorithm takes as its input a start day, an end day, a set of employees and information about their roles, a set of tasks and information about when the tasks should be performed.

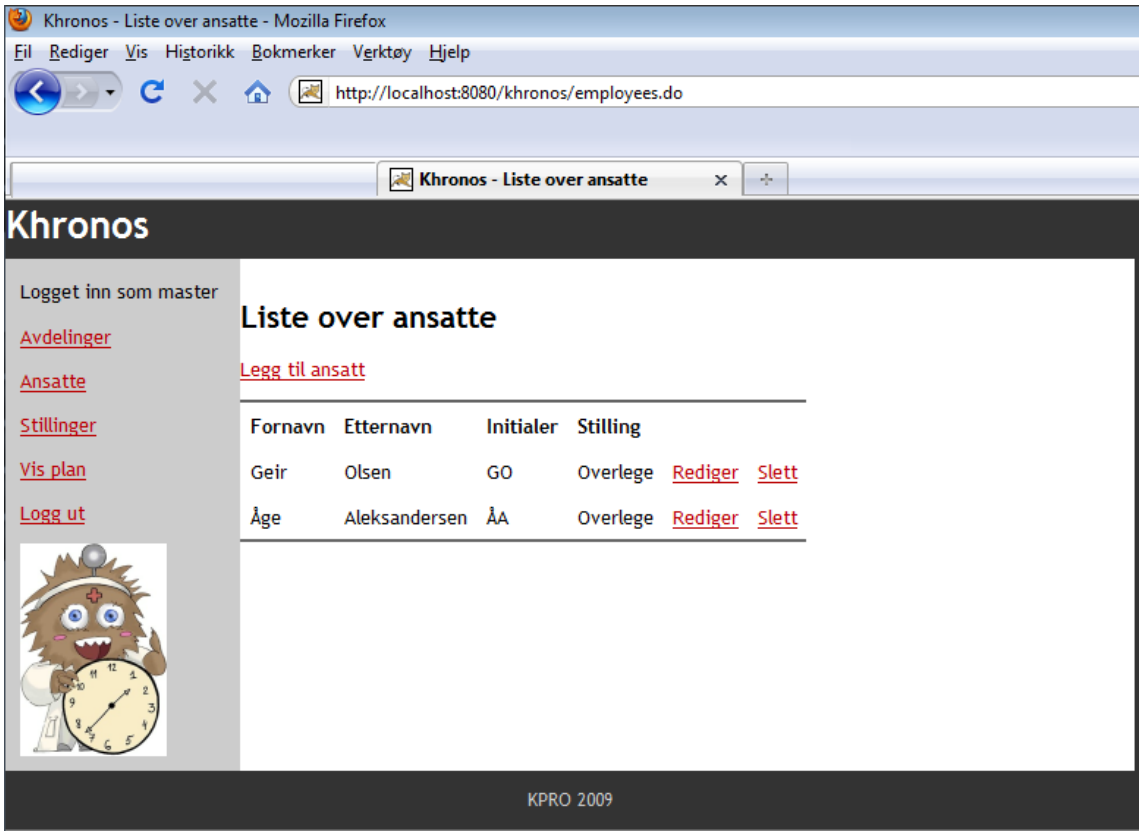

Figure 6.1: Screenshot: Showing Employees

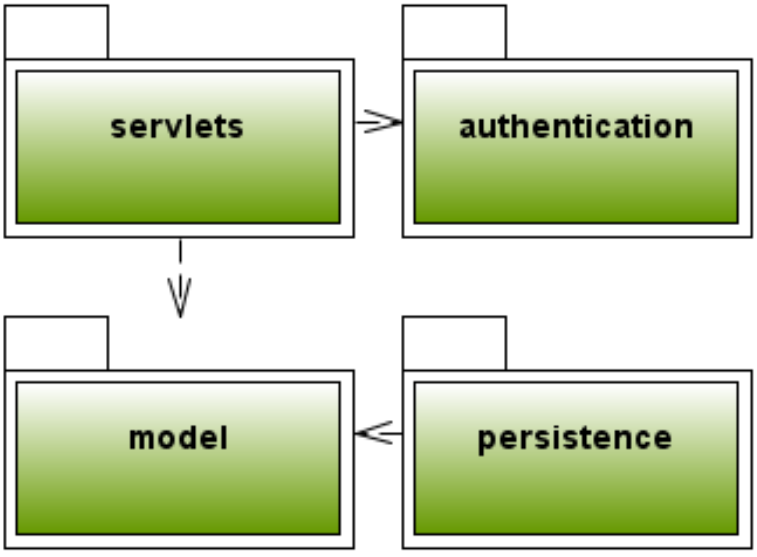

Figure 6.2: Package overview

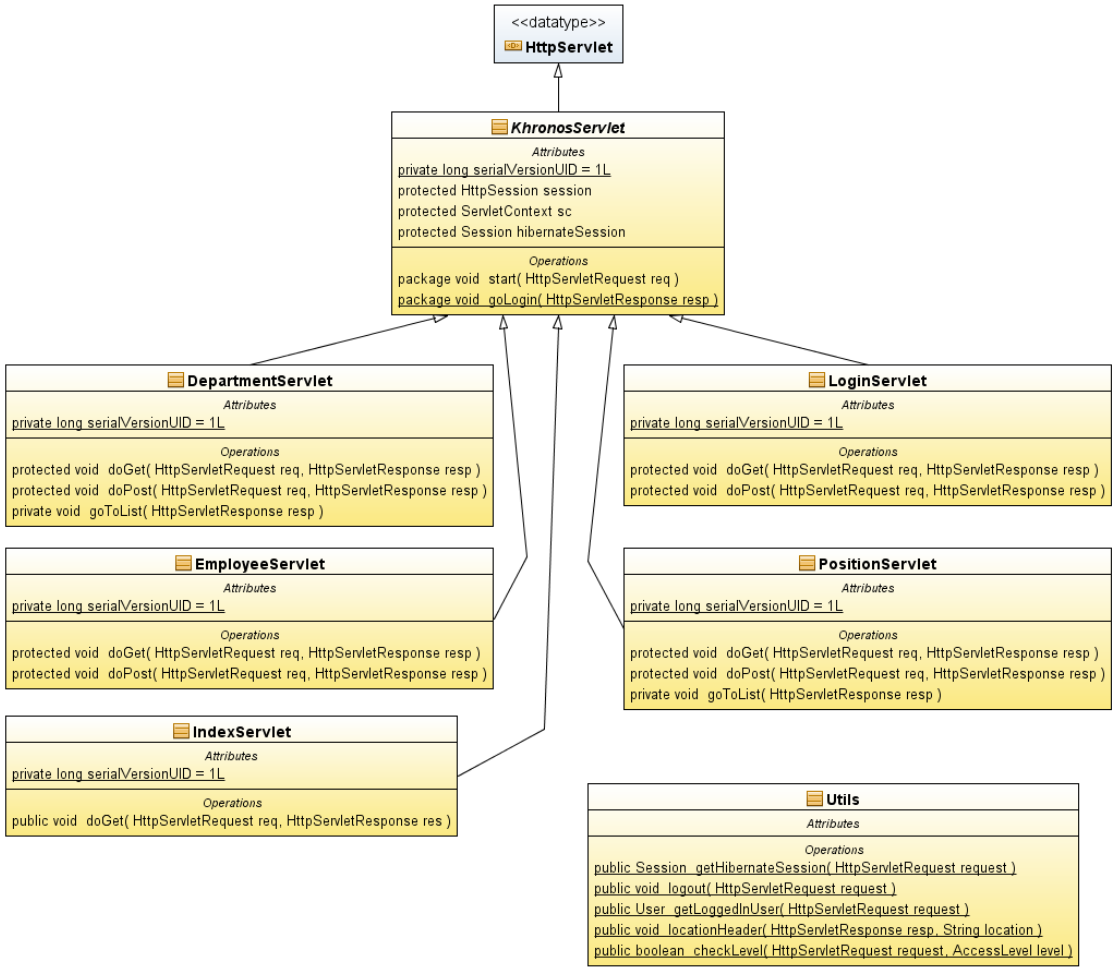

Figure 6.3: Class diagram: Package: servlets

Then it goes through the days, starting at the given start day, and for each task to be performed that day, it tries to find an employee that can perform it. An employee may be blocked from performing the task because he/she worked too recently, or because of other duties.

6.2.2 Web application

The web application was set up, and worked nicely on a Tomcat server. It was deployed as a .war file, and was therefore easy to deploy on different servers. The database was still set up on a personal web hosting account belonging to a group member. In the next sprint, we would work to get it set up on a server at IDI.

To make the web application, we configured the context to map different URLs to different servlets. We made our own `KhronosServlet`, which extends `HTTPServlet`, adding a few methods to ease the use of sessions and authentication. Our servlets then extended `KhronosServlet`. This can be seen in Figure 6.3

6.2.3 Servlets

The basic parts of the `HTTPServlet` are the methods `doGet()` and `doPost()`. These handle the different HTTP requests, namely GET and POST. GET is used for most requests, the static pages, and basic information retrieval. These are the requests you send when you click a link. POST is used when you submit a form. They can both include parameters, GET by specifying them in the URL, with a trailing query (everything right of a question mark), and POST sends them in a way that is invisible for the user. By passing parameters, and separating between GET and POST, a servlet can be used in several ways. One example is shown in the sequence diagram in Figure 6.7. The servlet named LoginServlet shows a login page when `doGet()` is called, and validates supplied user credentials when `doPost()` is called.

`Utils` is a helper class, which the servlets use to access some information. `getLoggedInUser()` checks if the current session has saved a user object. If this is the case, then a user is logged in. `locationHeader()` is used to forward to any other URL, within or outside the domain. `checkLevel()` determines if the logged in user satisfies the specified `AccessLevel`, determining whether a user has the privileges he needs or not.

6.2.4 Authentication

The authentication could be improved in the future, therefore it was placed in its own package to be easilily replaced if needed. So far, there were two hard coded users (master/master and slave/slave). Master was given access like a Schedule Master, and slave access to view the plans (as a regular employee). This package is shown in figure 6.4.

6.2.5 Model

The model was not changed a lot from the last sprint, but more details have been added to the diagram. This is shown in figure 6.5. We were still open to change it some more, as the Schedule part was taking time to develop, and naturally would affect the domain model.

All classes were given default constructors and setter/getter pairs for every persistent variable. This is required to be able to use Hibernate.

As can be seen, `Department` was not yet connected to the model, but was meant to be connected to `Task`. A task belongs to a specific department. We also planned to connect `Employee` to `Department`, as each employee normally belongs in a given department.

`Task` now contained a lot of methods to set and get different variables. We used a boolean for every week day, to specify whether the task is performed on the given day. These booleans were saved in the database, giving a column for every week day. In addition, we provided convenient setters/getters using the Collections framework. This enabled us to call `getDays()` to get a Set of days on which the task will be performed, and `setDays()` to set all the days using one Set.

The class `YearWeekDayPK` was used to make a composite primary key in the `Day` table of the database. This means that `YearWeekDayPK` in the Day table makes

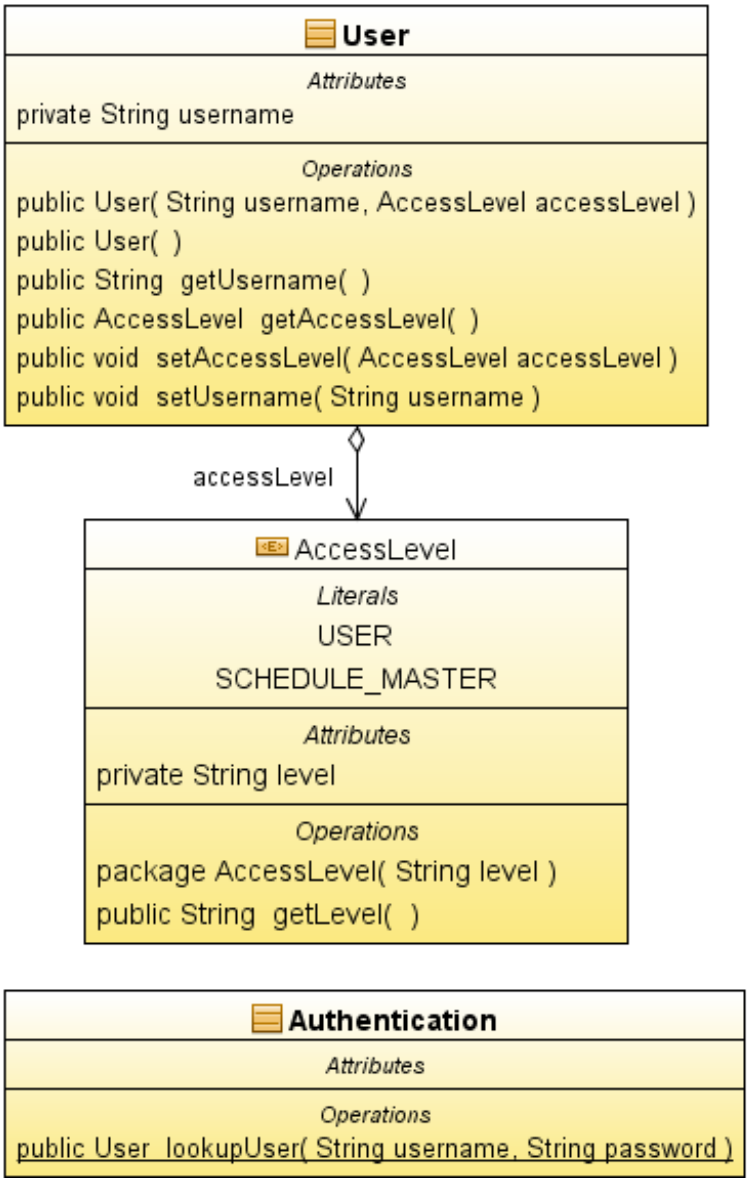

Figure 6.4: Class diagram: Package: authentication

three fields, namely year, weeknumber and weekday. `Weekday` was an enumerable type.

The classes `Schedule` and `ScheduleRow` were made for storing a generated schedule in the database.

6.2.6 Persistence

Persistence still only contained the class `HibernateUtil`, which sets up the Hibernate environment, and initializes the connection pool and session factory. We added some methods, to keep a `HibernateSession` connected to each `HTTPSession`. When a `HTTPSession` wants a `HibernateSession`, it calls the `HibernateUtil.getSession(String id)`, which returns the existing session if there is one, or creates a new one if not. The id is the auto-generated id belonging to the `HTTPSession`. This is then put into a `HashMap`, which keeps the HibernateSession alive until `closeSession(String id)` is called with the same id. This method closes all the sessions, and is only called when the server is shutting down.

6.2.7 Integrated Development Environment (IDE)

As we converted to making a web application instead of a Java Spring app, we also changed the main IDE. NetBeans has very good built-in support for developing web applications, with tools for modifying the database structure, and building and deploying the web application itself. It can also control different web servers, like Tomcat, so that building and running the newest version can be done in a matter of seconds. It is also evident that the different UML tools NetBeans provide are better than similar plugins for Eclipse.

6.3 Testing

In this sprint it was important to both test many new functions in the program and also communicate with the customer about how a user will interact with the program. During the development, we continuously used the system to verify new functionality. A customer meeting was conducted to gather more requirements and discuss our understanding of details of the task with the customer.

6.3.1 Graphical User Interface

We also had the initial usability testing with the customer. We did not focus on the usability of the GUI itself, but rather on the functions we wanted to include in the program which the customer would interact with. The customer, after getting some explanations, approved and agreed on our thoughts on the functions a schedule master and ordinary users would need.

6.3.2 Scheduling

As we worked on implementing the new scheduling rules gathered from the customer we verified the output against their plan and our expected results. Some flaws were

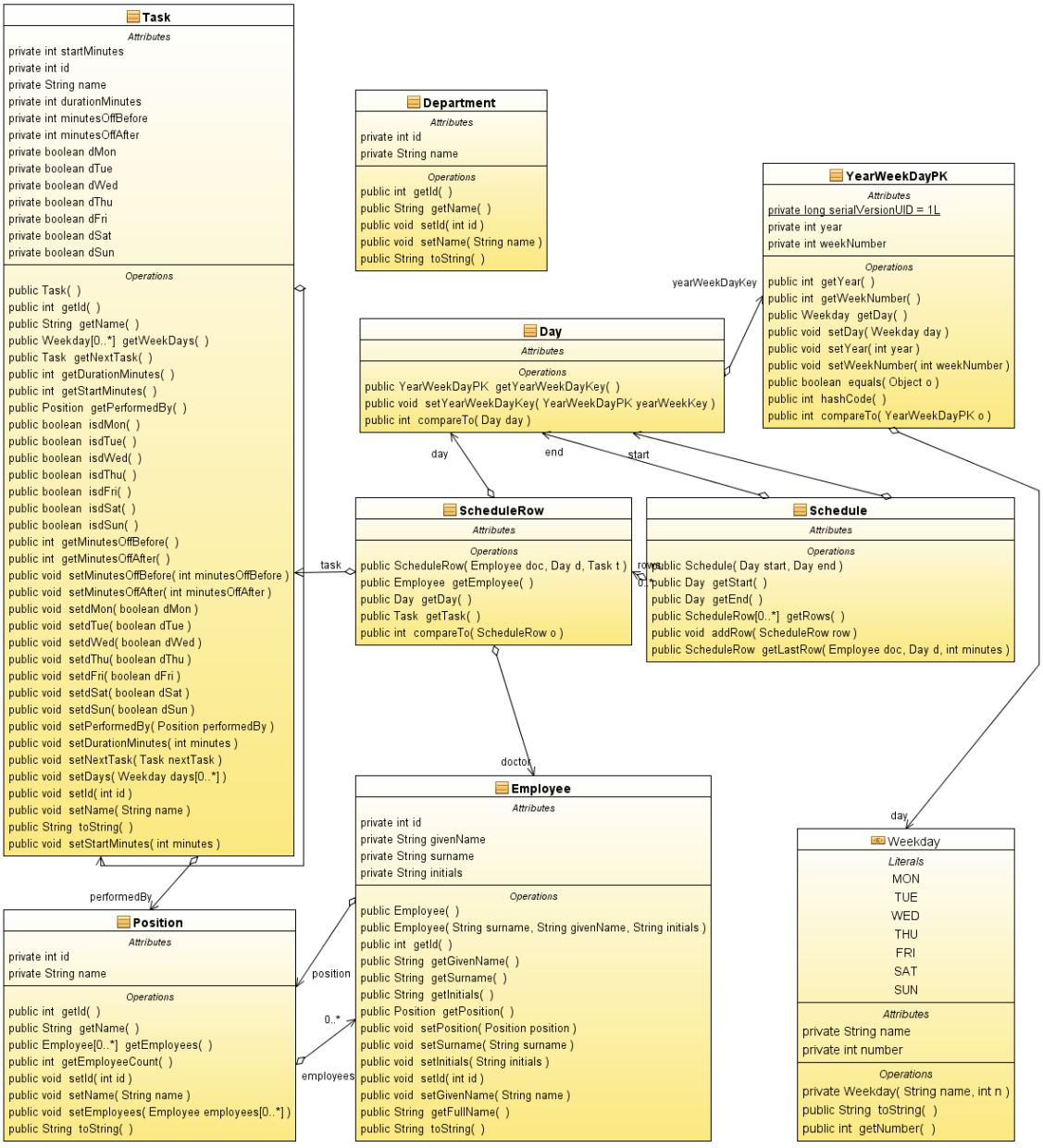

Figure 6.5: Class diagram: Package: model

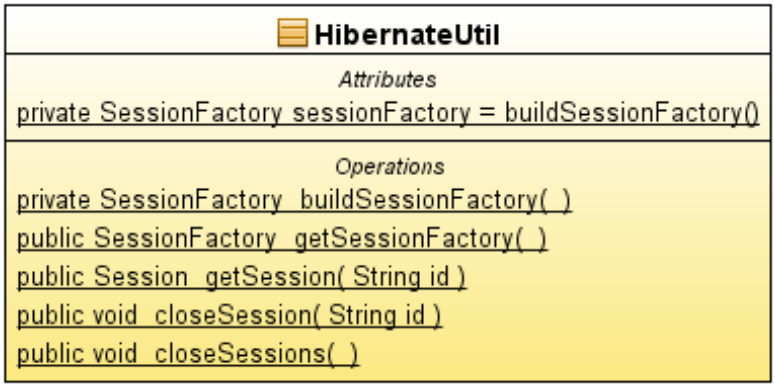

Figure 6.6: Class diagram: Package: persistence

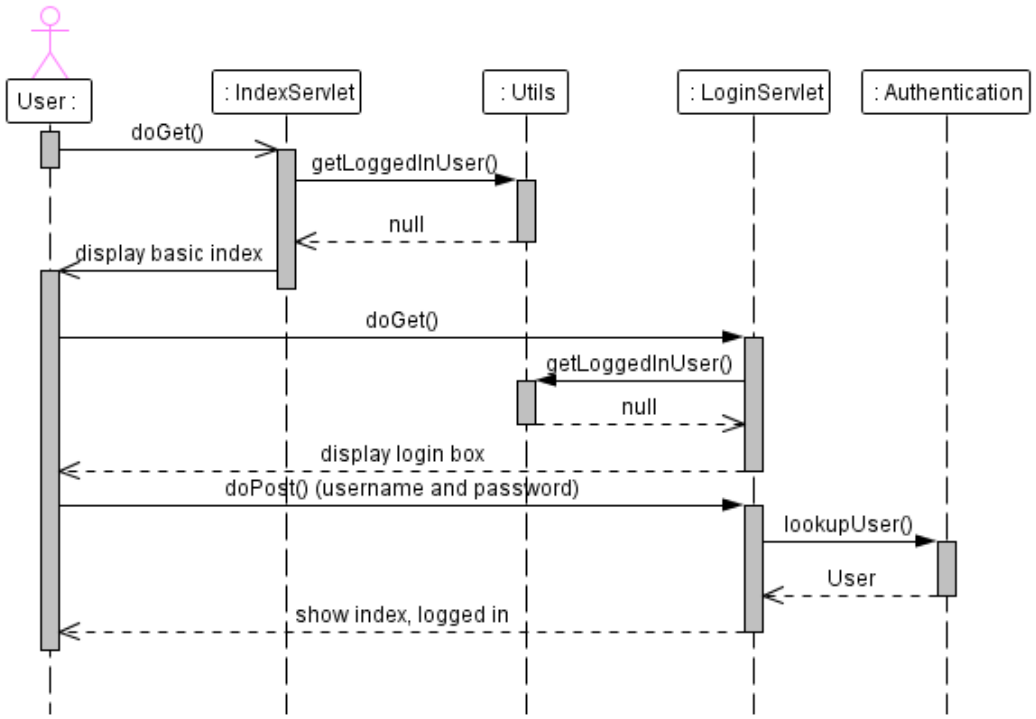

Figure 6.7: Sequence diagram: Log in

found and corrected this way.

6.3.3 Database

As we adjusted the model to contain the classes needed for scheduling we had to redo some of the Hibernate mappings and write some new ones as well. This required verification that we were storing the objects correctly and were able to retrieve them. We wrote code to verify this.

6.4 Evaluation

In sprint 1 we laid the foundation of the program. It was easy to know what needed to be done next, and we had a fairly good idea where we were in the process. In sprint 2 it was different because of a number of reasons, though despite the problems we managed to advance greatly with the implementation.

6.4.1 Review Meeting

Also present at this sprint review meeting was the customer. This gave us the opportunity to both demonstrate the completed work so far, and get valuable comments which we needed for our further work.

As the burn down chart in Section 6.4.2 shows, not all of the planned work was finished. Trouble with Tomcat made the *ToDo* higher in the beginning. Realizing that we needed more time on the scheduling method in particular made it higher in the end, and was also the reason that not all the planned work was completed. It is clear that some of our estimates were wrong in this sprint, and that some tasks took more time than expected. One reason for this could be inexperience, but another reason is the fact that we simply did not predict the complexity of some aspects of the algorithm. There are many constraints the algorithm must take into account, and it was not easy to see how complex they were. Still, we got a good idea of how much work remained on these tasks. So we did not look at this as a failure, but rather something we could learn from and be better prepared for the future.

We also encountered a few more problems with VersionOne, mainly that it was impossible to change anything else than what is going on at the current day. So if a group member forgot to register the work hours one day, he or she could not go back and change it, the only option was to register it on the current day. Again, as in the first sprint, this did not influence the process much. In fact, the only thing it did was to increase our awareness of how strict parts of Scrum can be, and that agile methods was still very new to us.

6.4.2 Burn Down Chart

Figure 6.8 clearly shows that everything did not go as planned in this sprint, and that we had to discuss what to do with the work that we did not get to finish.

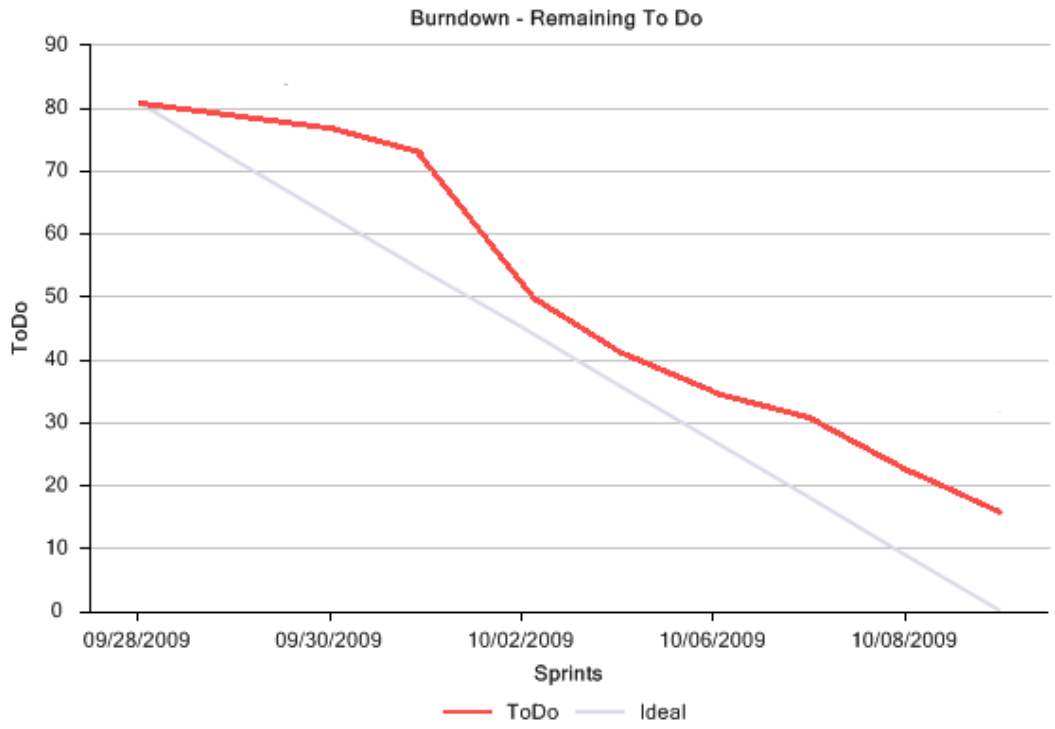

Figure 6.8: Burn down chart

6.4.3 Work Progress

As we had never developed a web application or set up a Tomcat server before, it was a process of much trial and error. IDE plugins were available to do some of the work, so it was not too hard to get it up and running. There was, however a strange problem while rendering JSP files. After many hours of trying to fix this, we found out that a DTD specification was pointing to the wrong version, which gave strange results. This was not very clear, as there was no version number in the DTD URL, but there had been put in "/jsp/" in the middle of the path.

Not all GUI functions were finished, as we were still waiting for the scheduling functionality to be developed further.

Still, huge progress was made on the implementation.

The scheduling logic from the prototype was migrated into the main program and integrated with the model objects already present.

6.4.4 Retrospective

There was much to discus concerning this last sprint. The burn down chart illustrated that the sprint did not go as fast as planned, and we needed to reflect on the reasons for this. As mentioned above, time consuming problems occurred, but that was not the only reason. We agreed that we did not have the necessary experience to make accurate estimates for such a large project, and that we should have paid more time and attention to estimating the tasks because of this. Still, it was a valuable lesson for the group.

CHAPTER 7

Sprint 3

This is the third and second to last sprint in our project. In this sprint we hoped to have the program near completion, so that the customer could test it, and we could use the last sprint for bug fixing and smaller fixes the customer might come up with.

7.1 Planning

With the shortcomings in sprint 2, we put more thought into the planning of this sprint. We focused on making the goals and tasks clearer and tried to make better estimates. We also decided to finish all the work that we failed to finish in sprint 2, since all of it was vital for our program to work properly.

7.1.1 Goals

We aimed to have the program close to completion, or at least have a clear idea of how much more work needed to be done. We tried to have a prototype ready for the customer to try and test out. For this we would also set up a server to run the program.

7.1.2 Sprint Backlog

ID	Priority	Description	Req.	Hours est.	Hours used	Responsible
1.7	High	Implement view for the schedule	NF04	8	8	Arve
1.8	High	Connect the GUI together	NF04	8	8	Arve
1.9	High	Improve GUI layout	NF04	6	6	Arve
1.10	High	GUI Implementation, employees, departments and tasks	NF11	8	9	Arve
2.8	High	Scheduling, distribute workers among tasks	NF08	20	20	Petter
2.9	High	Add constraints to schedule method	NF10	8	9	Petter
6.3	Low	Test cases	NF08	8	8	Petter
1.11	Low	Document GUI design	NF04	6	5	Thorbjørn
4.5	Low	Extend class hierarchy documentation (UML)	None	4	4	Arve
4.6	Low	Sequence diagrams	None	3	3	Arve
			Sum:	79	80	

Table 7.1: Sprint 3 Backlog

7.2 Design and Implementation

The model was extended slightly, so that tasks are now grouped in task categories. This facilitates viewing schedules in a more tidy way. More work has been done on both the web-app and the scheduling algorithm. To be able to put more work into the implementation itself, the updated diagrams will be put in Chapter 9 (Overall System Design).

7.2.1 Web-application

The web-application has been developed further, introducing more views to access and edit the data. As the scheduling algorithm is not complete yet, it has been hard to know exactly how to implement the user interface.

A general calendar class was made to display months with numbered weeks. The calendar logic is based on `java.util.GregorianCalendar`, so that we did not have to reinvent the wheel by thinking of leap years, years with 52 or 53 weeks, etc. Different calendar libraries exist, but we did not find any that also show week numbers, and is as configurable as needed. The calendar generates HTML for either a month or a whole year, displaying it all in a clear manner. This is shown in Figure 7.1.

`YearWeekDayPK` has been phased out, as `Day` does not have to be a stand-alone entity. All functionality has therefore been moved into the `Day` class. The class

`Utils` has been removed, and its functionality has been moved into the abstract class, `KhronosServlet`. This change was done, as the servlets were the only user of the class, and all the methods were helpers for servlets.

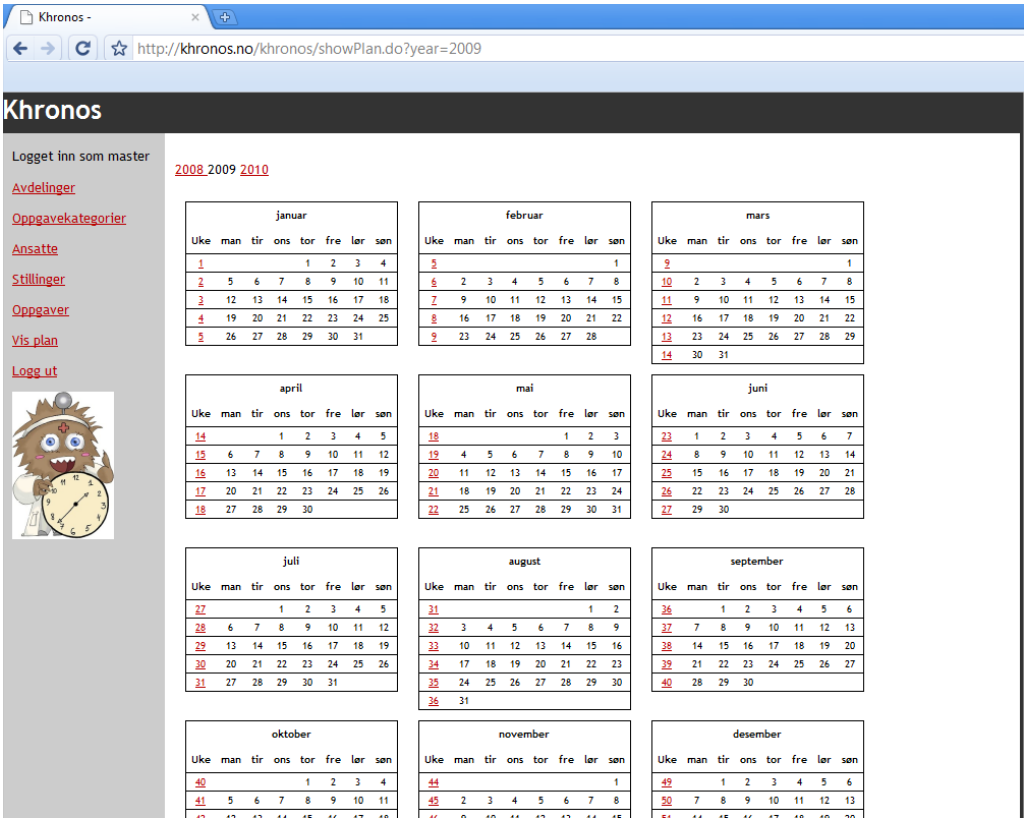

Figure 7.1: Screenshot of calendar

A schedule can now be planned and displayed through the user interface. There are still issues to be resolved, which will be done in the final sprint.

Small improvements have also been made to the graphical layout of the program. By coding the HTML in a well-structured way, and using CSS for layout, graphical changes to the web-application can be made by changing only the style sheet.

7.2.2 Domain and Server

We have bought the domain *khronos.no*, and have mapped this to a computer with fixed IP in the computer lab. It is now up and running, so that the customer and others can see the progress in an easy way. This makes us able to show the customer new solutions without having to schedule a new meeting every time. The web page is also accessible from the hospital network, so that the customer representatives can show the system to other interested employees.

7.2.3 Scheduling

Work continued on the planning algorithm. During a meeting with the customer we realized that their requirements were more static than we thought initially - their

weekly tasks are mostly fixed, but can be blocked by shift duty.

With this simplification in mind, the planner was restructured. We changed it from a single pass fully dynamic process into a two-pass process which during the first pass plans shifts, and during the second pass scheduled the fixed weekly plan for those doctors who do not have conflicting shifts.

The plans being output are starting to approach what the customer expects, but some work remains to make the planner perform exactly as specified.

7.3 Testing

We followed the normal process software developers do - making small changes, doing test runs and observing the output. The GUI was changed from the last sprint, but we did not conduct formal testing with the customer using the new GUI this sprint due to time constraints both on our end and on the customers end. Instead, we deployed the application to khronos.no and sent the URL to the customer, so that they could test when they had time. We got some positive feedback on the web interface, but decided that it needed some final changes to be usable and look professional. We scheduled these changes for the next sprint.

We wrote some JUnit tests, and a bug which would have gone unnoticed otherwise was discovered in the model, whereupon a Day which was otherwise equivalent to another Day, but did not have the same hour, minute and second information in its internal `GregorianCalendar` instance was not considered equal to the other day. As we only intended to use Day objects with day-level precision, this was not intended. The bug was corrected by explicitly resetting the unused fields.

7.4 Evaluation

The primary goal was to have the program ready for delivery after this sprint, and use sprint 4 for bug fixing and tweaking. This goal was not achieved, as the scheduler was not finished, as well as manually editing a schedule. If we did not finish the program, we agreed we should know exactly what work remained, and that we did.

7.4.1 Review Meeting

Although we did not have the program finished, we had most of it ready to show the customer. We discussed the different parts of the web page, and discussed the layout. An example of how the generated schedule would look and behave was also shown. It was important that the layout did not bring to much changes compared to the situation today. The more similar solution the better. Our choices seemed satisfying to the customer. It was also agreed that further communication between group members and the customer would be beneficial for the continued development of the scheduling algorithm. This primarily in the form of previous schedules to be sent via email from the customer in the near future. It was agreed that efforts would be made to have the scheduling algorithm in its final form by the end of the next sprint.

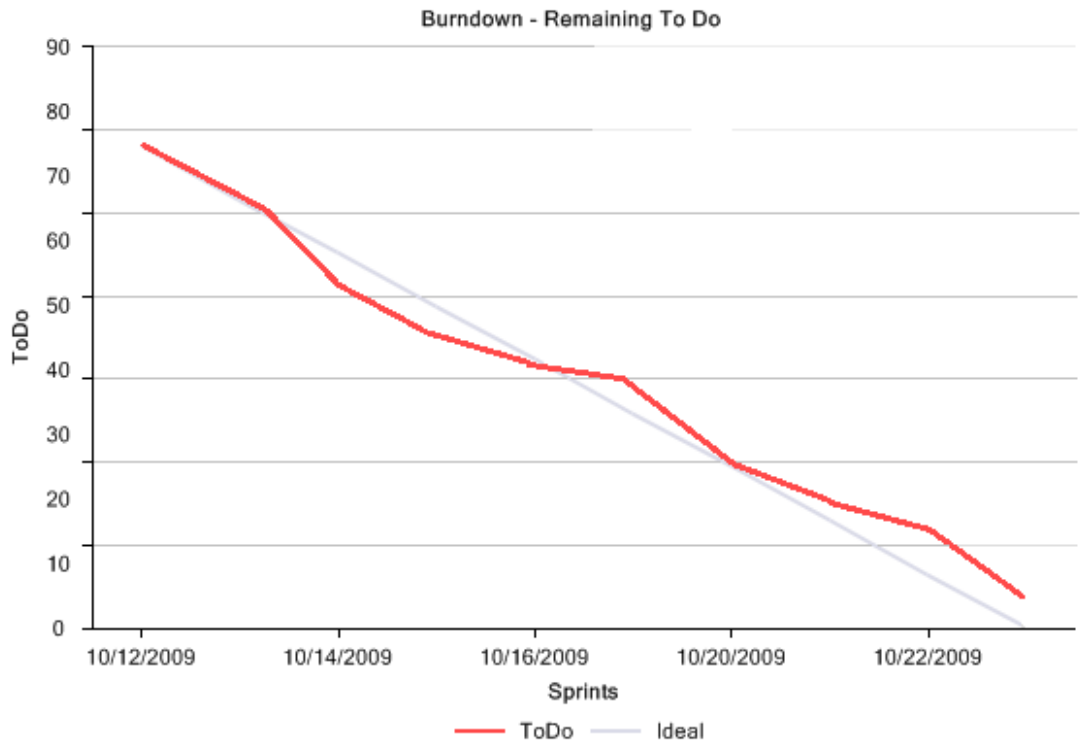

Figure 7.2: Burn down chart

One thing that might cause some uncertainty was a few additional constraints to the schedule algorithm. In our conversation with the customer, some constraints concerning dedicating work had to be added. At this point we did not know how much time this would take, and would consider it more on the planning meeting for sprint 4.

7.4.2 Burn Down Chart

Although a group member was ill the first week, we felt we were ahead of schedule for a while. Things went more smoothly compared to sprint two, and progress was swift. We did realize, however, that some extra constraints had to be made for the program to function properly. This meant that there was some work left over to the next sprint, and that we were not so close to completing the program as we had hoped. Still, we had a good idea of how much work that was left, and were confident we could finish it in the next sprint. Figure 7.2 displays the burn down chart from this sprint.

7.4.3 Work Progress

The program was not finished, but we had an estimate of how much work was remaining, and would be able to finish in the next sprint. Viewing and editing the schedule manually, a small part of the schedule itself and some more constraints were lacking. Work on the report took much of the time.

The scheduler was beginning to give sensible results. Meeting the customer again gave us valuable input regarding simplifying adjustments to make, and these were planned for the next sprint.

7.4.4 Retrospective

The working process went much smoother in this sprint. In general, the estimates we made were consistent with the actual hours we spent on them. Admittedly, the work in most of the tasks were much more defined in the planning of this sprint compared to sprint two, but we also felt that by using the experience earned from earlier sprints we were more capable of making estimates.

One problem we faced the first week of this sprint was that a group member was struck ill and was unable to do any work that week. This led to a dilemma; should we distribute the extra workload among the rest of us or should we handle it in correlation with the group member upon return? The work in question, fixing and adjusting different areas of the report, did not require immediate attention. We therefore decided to prioritize to continue as planned as we would if we were all there, and rather assist the member in catching up upon the return of said member.

People turning sick happens often in any working situation. One can only accept it and try to cope with it. In our case there was no crisis. The group member worked hard the following week and the rest of the group worked some hours extra to get finished.

CHAPTER 8

Sprint 4

The last sprint in our project. This was where we planned to tie all loose ends and deploy the program to the customer.

8.1 Planning

As the project was close to the end, it was important to have the right priorities. If there were aspects of the system which some might not get implemented because of lack of time, we needed to prioritize the most important ones. The extra constraints introduced to us in the previous sprint review meting added some work. We thought we might have to change the logic a bit, so it was not easy to predict exactly how much work this sprint would involve. A system test would be performed at the end of the sprint. We also needed to prepare for the delivery presentation and to make a proper user manual.

8.1.1 Goals

We needed to tie up all the loose ends and finish the program. If there was time to spare we would add some functionality to increase user friendliness.

8.1.2 Sprint Backlog

ID	Priority	Description	Req.	Hours est.	Hours used	Responsible
1.12	High	Improve view for the schedule	NF04	5	5	Arve
1.13	High	Implement the ability to choose time period to view	F10	1	1	Arve
1.14	High	Implement attribute editing	F06	3	4	Arve
2.10	High	Add more constraints to the scheduler	F01	10	12	Petter
6.4	High	System test	All	8	8	Petter
6.5	Medium	Document system test	None	8	8	Even
5.4	Medium	User manual	None	8	8	Even
4.5	Low	Add more sequence diagrams	None	5	6	Arve
6.6	Low	Unit tests	NF07	8	8	Petter
5.5	Low	Document overall system design	None	1	2	Arve
5.6	Low	Prepare for system delivery	None	6	7	Thorbjørn
4.7	Low	Additional sequence diagrams	None	1	1	Arve
4.8	Low	Further extend class hierarchy documentation	None	4	4	Arve
			Sum:	68	74	

Table 8.1: Sprint 4 Backlog

8.2 Logo

At this point, concerns were raised that the logo did not have the professional feel that we wished to convey to our customer in this project. Therefore a second logo was created, with a more sterile feel. The old logo was removed from the program, but the new one was not put in its place. The new logo was only placed on this report. The name was kept unchanged.

8.3 Implementation

In this sprint, the plan was to generally wrap up the implementation. This meant quite a lot of work, as the GUI implementation was still waiting for the scheduling algorithm to work correctly. Also, we saw the need for new classes to fit the final requirements.

8.3.1 Design

`TaskCategory` was introduced to collect similar tasks in groups. This enables printing the schedule in the same way that is done by the customer in their current template. By giving this category a boolean value, specifying if it should be scheduled automatically or not, this also lets us separate the logic handling of shifts versus the daily tasks.

As most tasks are to be scheduled on a fixed, weekly basis, it was obvious that we needed a weekly plan for each person. This is specified by the class `WeekPlan`. This has a many-to-many relation to `Task`: a week plan could contain several tasks, and a task could appear in several week plans. The way to implement this for use with Hibernate, is by adding a class in the middle, namely `WeekPlanTask`. This was also implemented. `WeekPlan` has a one-to-many connection to `Employee`, meaning that several employees could work the same weekly plan. The updated class diagram for the model package is shown in Figure 8.1.

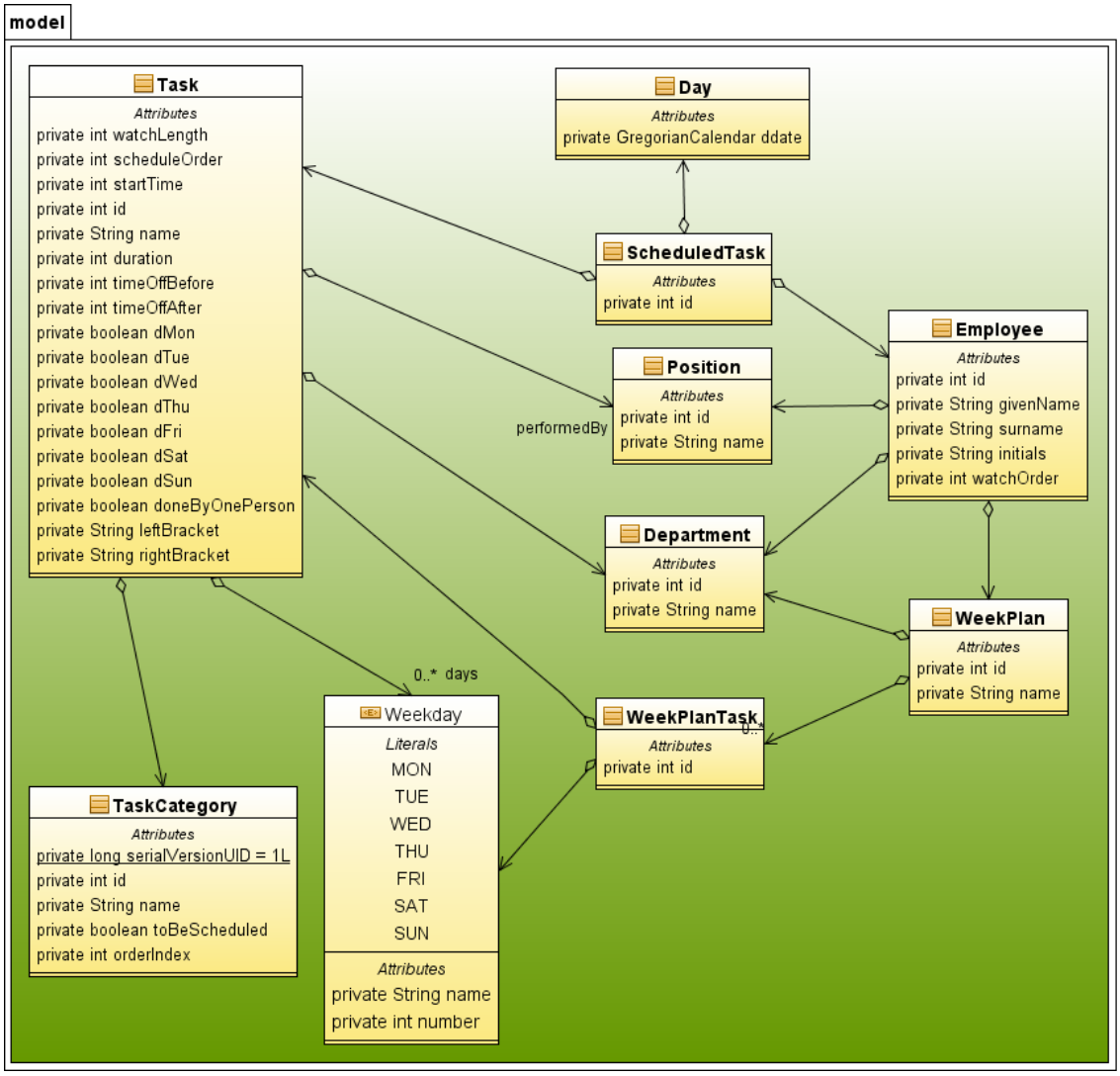

Figure 8.1: Class diagram: model package

To be able to insert the test data provided by the customer in an easy way, a servlet, `InsertTestData`, was made to add the data into an empty database. This proved really useful when testing, as emptying the database and inserting the needed data could be done in a few seconds.

To suit the needs of the scheduling algorithm, an integer was added to `Employee`, to specify in which order each employee should be assigned to rotating shifts. If this integer is not given by the schedule master, the employees will have shifts in the order they are returned by the database.

New features were added to the servlet for making a plan so that an employee can be manually assigned to a task. This also checks if the employee is free to work in the given period, alerting the user with an error message if he is already scheduled to do something else at the same time. This feature was important to the customer, as setting a person to do two tasks in one time today can be hard to spot.

The MySQL database was moved to be hosted locally on the server, which yielded a significant speedup. On the system we were allotted by NTNU it now takes the system 12 seconds to plan a complete year. With the old database setup which connected over the Internet, this took close to a minute for a single month.

Quite a few bugs were uncovered while developing new features. These were fixed. They are not described here, as they were all fixed by doing small changes to the code and checking the output as one progresses, the way one normally does while developing software.

8.3.2 Scheduling

The scheduling changes introduced during the last sprint were completed, and the two-pass process was refined to take dependencies between tasks into consideration. A task which causes a subsequent task to be performed by the same person will now be scheduled before the its dependent tasks. In the customers domain, this is illustrated by assistant doctors having day shift on a weekend causing them to get ward duty during the subsequent week.

A shift order attribute was added to the Employee class, and all employees having the same Position will have shifts in the order given by this attribute.

The changes to the scheduler to take inter-Task dependencies into consideration required updating the GUI to allow the user to supply the dependency information. It is recognized that how to enter this information in a consistent manner may not be immediately obvious to all users, but due to time constraints, this is the way it was done. With more time to work on the system, an automatic dependency resolver could be added, and this would yield a big gain in usability.

8.4 Final View

Before, the planing was done manually by typing data in a giant table in a text editing program. The table was a black and white table over flooded with details. Too much details destroys more then it helps, the table is indeed very hard to look at. Black and white are bright contrasts to each other and makes it harder too look at, especially when there is so much text and the table cramps everything together Figure 8.2.

		PRIM VAKT	SEK VAK	AVD	OPERASJON	POLIKL.	ADM	FRAVÆR
1	T	(JL/FH)[.]WT	LH	KS/RR/BS	(MB),AÅ,PM,EJ	LH,SY,,ER,NF	**36** WT(U) HA,HÅ(a)	VB,SN(P)
2	O	(WT/FH)[ER]NF	AÅ	KS/RR/BS	HA,LH,HÅ,ER,(JL),[PM]	(MB),EJ,BH	WT(U) AÅ,[JL],(PM)(a)	SY,BH(F2) VB,SN(P)
3	T	(NF/FH)[ER]BH.	LH.	KS/RR/BS	LH,SY,KK,ER,	HA,AÅ,JL,PM	WT(U) EJ(a)	VB,SN,HÅ(P)
4	F	(ER/FH/KS)NF	HÅ	RR/BS	JL,PM	HA,(SY),EJ	WT,AÅ(U) LH,[SY],[ER](a)	VB,SN,HÅ(P)
5	L	RR/NF	HÅ					
6	S	RR/NF	HÅ					
7	M	(NF/FH)[JL.].	SY	RR/SY	HA,HÅ,SN,VB,JL	LH,[BS],AÅ,BH	**37** EJ(U) (BS)(a)	ER(P) PM(F)
8	T	(/FH)[ER]JL	LH	KS/HÅ	(MB),BS,AÅ,RR,WT	LH,SY,SN,VB,ER,NF	EJ,HÅ(U) HA(a)	PM(F)
9	O	(JL/FH)[BH.]WT	VB	KS/[HÅ]	HA,LH,ER	(MB),[BS],SN,RR	EJ,(HÅ,(BS))(U) AÅ,VB,NF(a)	SY(F2) PM(F)
10	T	(WT/FH)[BH.]NF	HA	KS/[HÅ]	LH,[SY],BS,KK,ER,RR	HA,AÅ,VB,JL	EJ,(SY),(HÅ)(U) SN(a)	PM(F)
11	F	(NF/FH)WT	AÅ	KS/(HÅ)	AÅ,SN,VB,JL,[RR]	HA,(SY),BS,(ER)	EJ,[HÅ](U) LH,[SY],[ER],(RR)](a)	PM(F)
12	L	BH./WT	AÅ					
13	S	BH./WT	AÅ					
14	M	(WT)[KS]RR	VB	FH/AÅ	HA,VB,JL,EJ	LH,[BS],HÅ,KS,KB,PM	**38** WT(U) (BS),NF,SY(a)	SN(P)
15	T	(RR)[KS]PM	LH	FH/AÅ	(MB),BS,KS,EJ	LH,SY,KB(VB),JL,NF,ER	WT,[VB](U) HA,HÅ(a)	SN(P)
16	O	(PM)[NF]JL	EJ	FH/AÅ	HA,LH,HÅ,KS,ER	(MB),BS,KB,RR,EJ	WT(U) VB,NF(a)	SY(F2) SN(P)
17	T	(JL)[NF]WT	HA	FH/AÅ	LH,SY,BS,KK,RR	HA,HÅ,VB,KS,KB,PM	WT(U) NF,EJ,(ER)(a)**Elektronisk allmøte kl 1330**	SN(P)
18	F	(WT)JL	VB	FH/AÅ	VB,(KS),PM,[RR],NF	HA,(SY),BS,KB,EJ	WT(U) LH,HÅ,[SY],[KS],(RR)(a)	BH(2F) ER,SN(P)
19	L	ER/JL	VB					
20	S	ER/JL	VB					
21	M	(JL)[NF]FH	BS	ER/VB	HA,SY,SN	LH,[BS],HÅ,AÅ,PM,RR	**39** EJ(U) (BS),NF(a)	
22	T	(FH)[NF]RR	LH	KS/VB	BS,AÅ,PM	LH,JL,NF,SN,SY(HÅ)	EJ(U)	MB(P) (ER,HA,HÅ,WT,BH)T
23	O	(RR)[WT]PM	SN	KS/VB	LH,(JL),FH	(MB),BS,SN	EJ(U) AÅ,VB,[JL],NF(a)	SY(F2)(ER,HA,WT,HÅ,BH)T
24	T	(FH)[WT]JL	HA	KS/VB	LH,BS,KK,RR,SY	AÅ,(PM)	EJ(U) NF,SN(a) **Kl 1300 – smittevern - FOR**	(ER,HA,HÅ,WT,BH)T
25	F	(FH)PM	SY	KS/VB	AÅ,(ER),[RR],NF,SN,(JL)	HA,(SY),BS,BH	EJ(U) LH,HÅ,[SY],[ER],(RR)(a)	
26	L	KS/PM	SY					
27	S	KS/PM	SY					

Figure 8.2: Old plan

The old plan was far from perfect and there was plenty of room for improvements in this plan. We wanted to make a plan that was easier to look at and easy to get the information you need from, yet we did not want to make the plan too different from what the customer was used to. The new plan should be easy to understand for everyone who is used to the old plan. With this in mind, we have deliberately tried to make the new plan almost the same as the old plan. Still we wanted the plan to be more presentable, making it easy and fast to find the information you need from the plan. We tried to cut down on the level of details and change how to present the data to make it more manageable. Colors is an important tool in presenting data, it is hard for the eye to look at colors that stand in strong contrast to each other. Since our customer is a hospital, we wanted to choose colors that would suit the customer, but also help us in our task to present the plan. We have used a palette of different blue colors, blue is a calming color and often associated with trust. These are both key elements that we wanted to give our customer and use to make the plan easy to look at Figure 8.3. We think that the new plan is a great improvement of the old one and it will make a big difference to the people that has to look at this plan to find out when he has to work and even more for the one that has to make the plan.

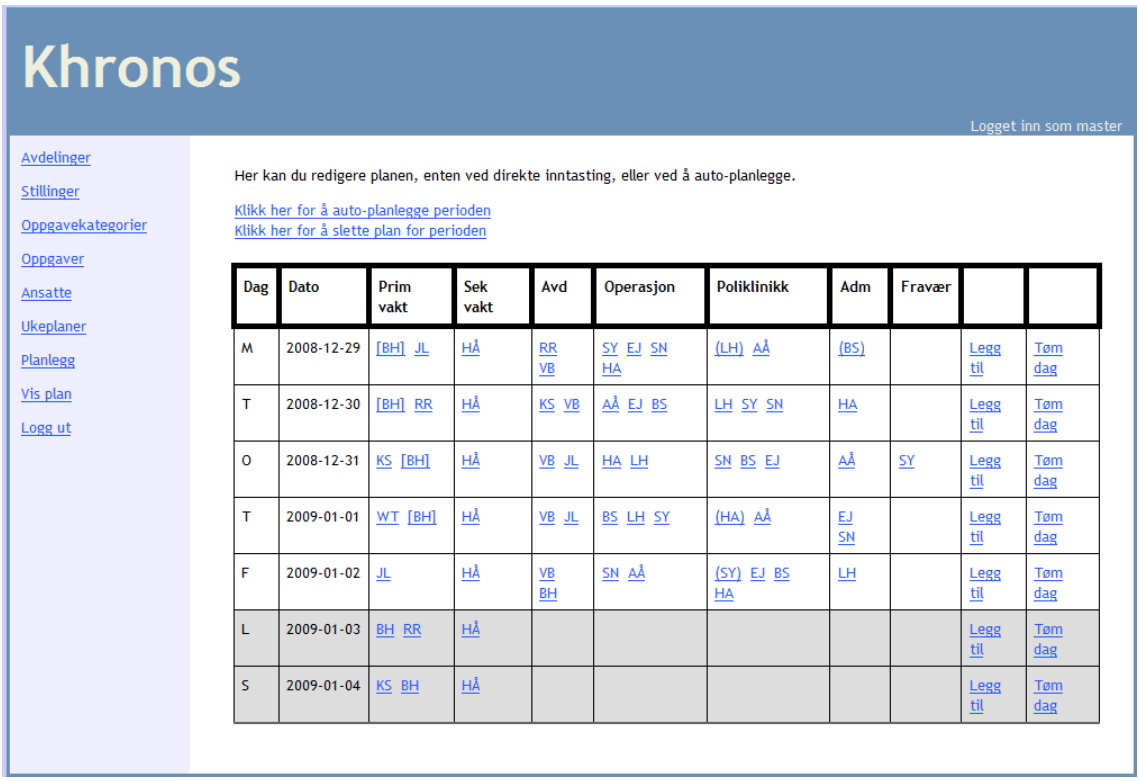
Khronos
Logget inn som master
Avdelinger
Stillinger
Oppgavekategorier
Oppgaver
Ansatte
Ukeplaner
Planlegg
Vis plan
Logg ut
Her kan du redigere planen, enten ved direkte inntasting, eller ved å auto-planlegge.
Klikk her for å auto-planlegge perioden
Klikk her for å slette plan for perioden
Dag
Dato
Prim vakt
Sek vakt
Avd
Operasjon
Poliklinikk
Adm
Fravær
M 2008-12-29 [BH] JL HÅ RR VB SY EJ SN HA (LH) AÅ (BS) Legg til Tøm dag
T 2008-12-30 [BH] RR HÅ KS VB AÅ EJ BS LH SY SN HA Legg til Tøm dag
O 2008-12-31 KS [BH] HÅ VB JL HA LH SN BS EJ AÅ SY Legg til Tøm dag
T 2009-01-01 WT [BH] HÅ VB JL BS LH SY (HA) AÅ EJ SN Legg til Tøm dag
F 2009-01-02 JL HÅ VB BH SN AÅ (SY) EJ BS HA LH Legg til Tøm dag
L 2009-01-03 BH RR HÅ Legg til Tøm dag
S 2009-01-04 KS BH HÅ Legg til Tøm dag

Figure 8.3: New plan

8.5 Testing

Although every sprint involved some unit and integration testing, more testing was required for this sprint. At the point of completion, a system test was needed to test that the system functioned as intended, and to assess the completion of the functional requirements set forth by the customer. The system test plan in Appendix E, created after the functional requirements were gathered, was run. The results are shown in Table 8.2. Based on this test, the group deemed the product to have been completed to spesification.

Test ID	Result	Comments
Sys001	Passed	N/A
Sys002	Passed	N/A
Sys003	Passed	N/A
Sys004	Passed	N/A
Sys005	Passed	N/A
Sys006	Passed	N/A
Sys007	N/A	Printing was not implemented as a function of the system. Instead, the printing function available in browsers was used. Selecting print in the browser while viewing the plan results in the plan, and only the plan, being printed.
Sys008	Passed	N/A
Sys009	Passed	N/A
Sys010	Passed	N/A
Sys011	Fail / N/A	Although this test fails, a different approach was implemented in the system. Instead of explicitly attaching one employee to another, two employees can be linked by having them follow the same week plan, or creating week plans for them that overlap where desired if more granular control is required

Table 8.2: System test results

All system tests except for Sys007 and Sys011 passed.
Sys007 was handled with existing web browser and CSS functionality instead of explicit implementation. Better results were achieved in less time by doing it this way.
Sys011 was handled as implicit functionality instead of by explicit implementation, and in the end this makes more sense in the system context, as the person setting up the system is already required to enter weekly plans and assign them to individuals if so desired. Adding an option for explicitly linking a person with another would override the weekly plans, and take control away from the user.

8.6 Evaluation

The plans we had for implementing bonus features for the program in this sprint got disrupted by documentation and report writing. In the end this was to be expected, as the report is what we are evaluated by. Still, we made a product that we were sure would be more effective and a significant improvement over the way the customer schedules manually at the moment.

8.6.1 Review Meeting

Except for a few functions not connected properly to the GUI, the program was practically done. We showed the customer all the completed work, such as viewing and generating a schedule, attribute editing and adding and deleting employees,

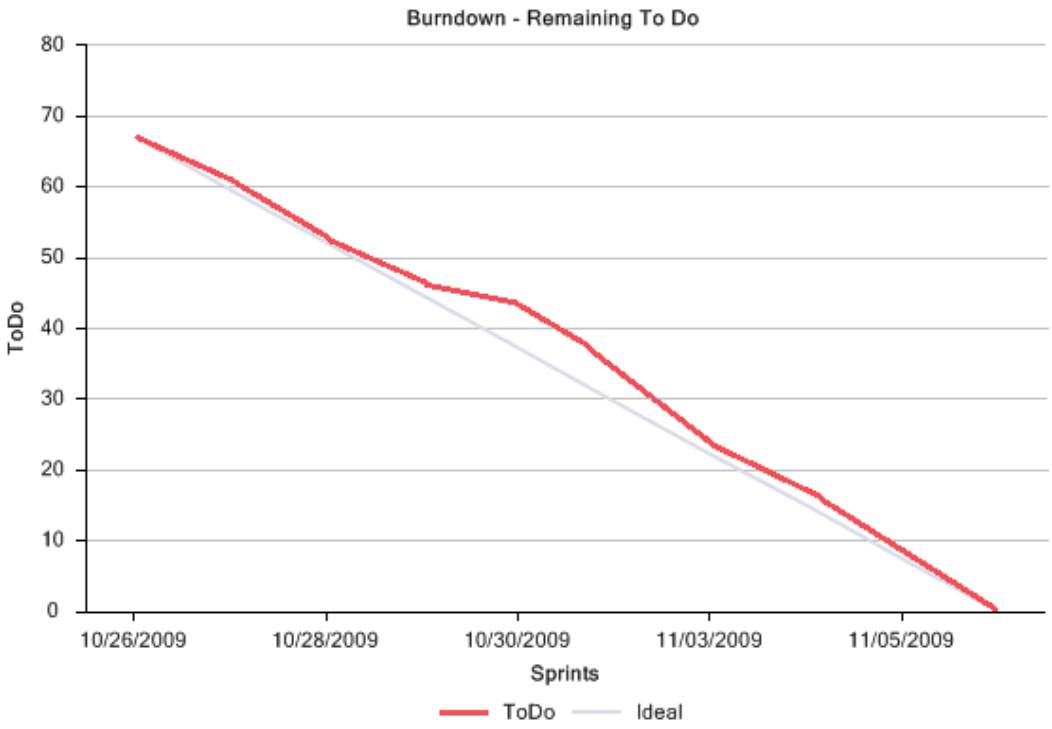

Figure 8.4: Burn down chart

tasks and departments. The GUI had also been modified with a more professional look, with colors that were often used in other health care related software.

We explained how the optional requirement regarding export to the iCal format could not be done within the remaining time. iCal would require synchronization that would take a while to implement, and we would most likely run into some problems since we are unexperienced with it. If the customer decides to further develop this program, iCal export ability would be a natural extension so that the schedule would become easy to integrate into other software, as iCal is one of the most popular calendar data formats today. However, the web page can of course be accessed and viewed on a smartphone.

8.6.2 Burn Down Chart

According to the burn down chart in Figure 8.4, we were pretty much on schedule throughout the sprint. A small bump in the middle of the sprint appeared because a team member was sick for three days. When that person came back, we quickly recovered.

8.6.3 Work Progress

After this final sprint, we had a working program that should be useful for the customer.

The scheduler was able to plan the shift rotation of the employees, including inter-task dependencies. It also handles the fixed duties for each employee with a

weekly plan which is only applied to the current week if the employee does not have shift duty which blocks it.

We had hoped we had time to implement some additional features that would increase usability, like exporting in the iCal format for example. Unfortunately, we did not have time for this. We did, however, spend some hours on tweaking the program to gain increased usability. We also made sure that the requirements were solved in a satisfactory way. All in all, the program has evolved to something we believe would be of great assistance to the customer. The only things that were lacking were a few functions not being connected to the GUI properly. We knew this to be an easy fix, and would have a finished program just a few days after this sprint.

8.6.4 Retrospective

Since this was the last sprint, we did not need to focus on process improvement for the rest of this project. However, we reflected on what to remember for future projects.

It was obvious for all the group members that we had become more and more comfortable with Scrum as the project progressed. Still, this only counted for the elements in Scrum we liked, for example the stand-up meetings, close customer interaction and not being bound to a single phase all the time as in the waterfall method. Things we were not that positive to, like the strict rules for tracking for example. So we ended up adopting a lightweight version of Scrum. One that we felt fitted the best for our project. After all, it was better to use something that we felt comfortable with, than to use something that felt like a burden. All the main elements in Scrum were still being used, but some in a less strict way.

We worked very hard in this sprint, both to write the report and implement the new constraints from the customer.

CHAPTER 9

Overall System Design

In this chapter, we will present the overall system design. Some of this has already been described in the sprint chapters, but as they were snapshots of current progress, some things will be repeated here. The system is split in several logical parts, working on different nodes. We will, therefore, start by explaining the different parts, and then drill down to explain how these different parts work.

9.1 Deployment

The system is made in a client-server pattern. The server runs on a dedicated computer, and the client is a web browser on a personal computer. Figure 9.1 shows a deployment diagram.

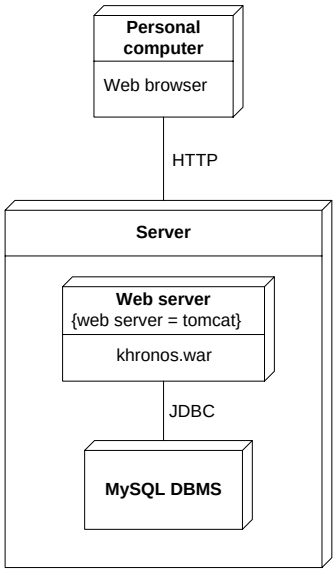

Figure 9.1: Deployment diagram

The program itself runs on a single computer, which is accessible through the Internet. The user then connects to this computer through a web browser on a personal computer. No browser-specific features have been used, so any fairly recent web browser may be used.

On the server, the web server itself will be running with the compiled program deployed (khronos.war). This has only been tested and deployed on a Tomcat server, but could be deployed on several different application servers, such as JBoss and GlassFish. The server needs some configuration, but a pre-configured server is included on the CD which follows the report.

The DBMS that we have used for the system is MySQL. As we use Hibernate, many other DBMSes could be used by changing only one line in the Hibernate configuration file.

9.2 The web application

The web application is built using servlets and JSP. These follow the Model-View-Controller (MVC) pattern, separating business logic from presentation. This is generally shown in Figure 9.2. When the user connects to the webpage with their web browser, the request is processed by a servlet. When the servlet has fetched the data as needed, and done the necessary calculations, the request is forwarded to the JSP processor, to display a specified JSP file. This will then generate HTML, which in the end is sent to the web browser, and displayed on screen. Section 9.3.4 will explain the servlets.

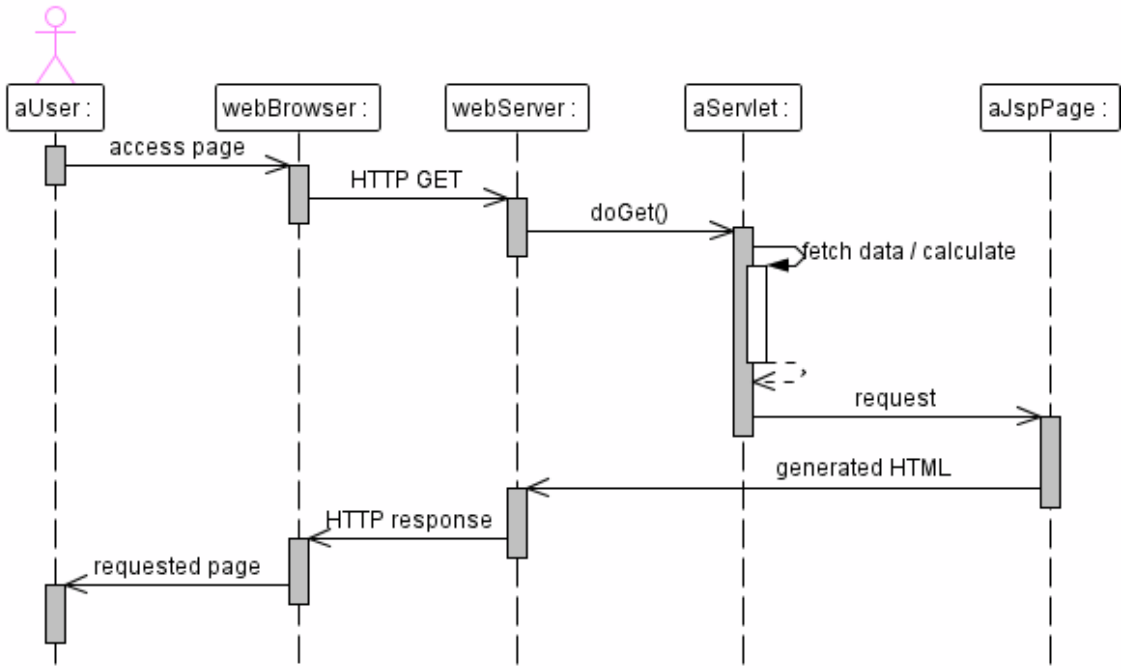

Figure 9.2: Sequence diagram: General call sequence, MVC

9.3 The Packages

The program is split in different packages, to keep related classes together, and to keep unrelated classes separate. This makes the code tree a lot tidier than if

everything was collected in one package. Figure 9.3 shows the different packages, which will be explained in greater detail in the following subsections. This diagram is quite densely connected. This could have looked tidier by serving all of the persistence functionality through the `model` package. We do, however, think that by putting it in between as shown in the diagram, the model class is not cluttered by having to serve extra functionality for persistence.

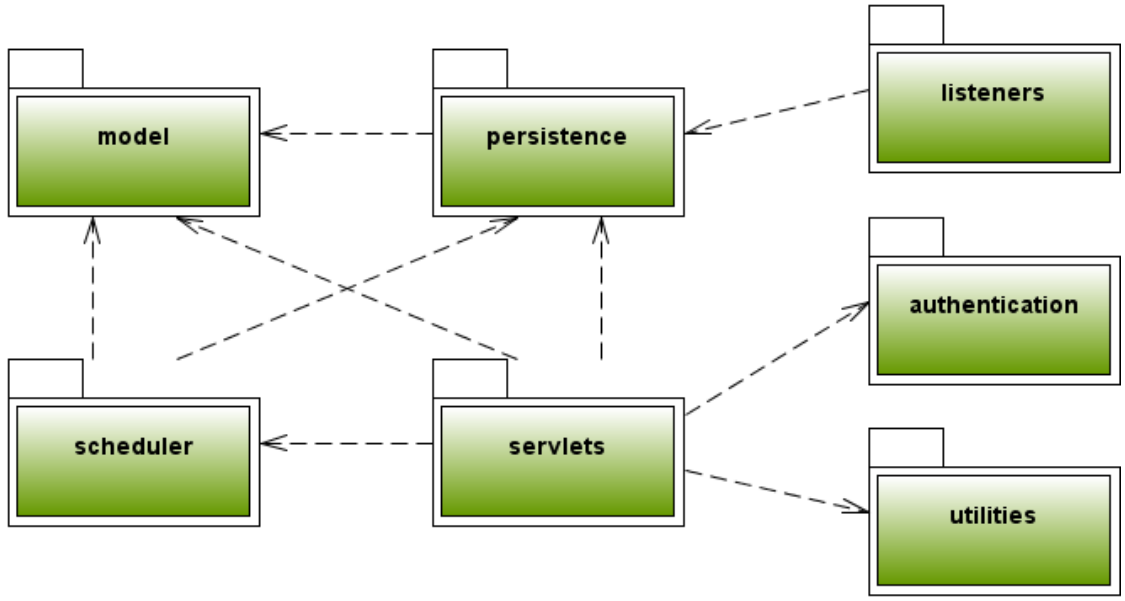

Figure 9.3: Package diagram: the different packages of Khronos

9.3.1 Model

The model package is the mapping between the real world and the program. Figure 9.4 shows a class diagram of this package. As these classes are mapped to Hibernate, they all need basic constructors, as well as setters and getters for every field. They have been annotated using Hibernate Annotations, which means that the mappings between the classes and the database are specified in the source files themselves. This simplifies the mapping, as the alternate is to specify them in a separate XML file, introducing more dependencies within the source files.

The `Employee` class represents an employee. An employee has a name and a `Position`, and works in a given `Department`. After schedules are made, the `Employee` will also have `ScheduledTasks`.

A `Position` is identified by a name. In the domain presented by the customer, the two available positions are "Senior Doctor" and "Junior Doctor".

The `Department` class represents the different departments that are to be scheduled. In the ENT department of St. Olav's hospital, this means several departments within the ENT department.

The `Task` class represents something which has to be done at a given time of day, a given series of weekdays, every week. These tasks are what this system will schedule. The task is identified by a name, and could be connected to a `Department`.

It could also be limited to a `Position`. In the domain presented by the customer, the different shift responsibilities are connected to positions. For instance, the junior doctors are the ones who have to work night shifts in the hospital. A task has a starting time and a duration, and is performed on specified days of the week.

Each task belongs to a `TaskCategory`. This could for example be *shift*, *operation* or *administration*. This makes the viewed schedule a lot tidier than if each task would get a separate column, and closer to the schedules used by the customer today.

Most of the weekly schedule consists of fixed tasks, that are specific for each employee. This is represented by the `WeekPlan` class. The week plan could be associated with a department. Several `Employee`s can share a `WeekPlan`, making them do the same tasks. As a `WeekPlan` usually consists of several `Task`s, and a `Task` could be part of several `WeekPlan`s, there is a many-to-many connection. This is realized with a mapping class, called `WeekPlanTask`. This also adds a `Weekday` as an attribute on the association, meaning that the task should be performed on the specified week day.

When a task is scheduled, it is linked to the class `ScheduledTask`. A `ScheduledTask` keeps track of one execution of a task, performed by one `Employee`, at one `Day`.

The `Day` class is made to make plans grouped in weekly parts. A day is therefore identified by year, week number and `Weekday`, even though it is persisted using `GregorianCalendar`. `Weekday` is an enumerable type, which is the most logical way to identify days (as there are seven pre-defined days, with no possibility that new ones will arrive).

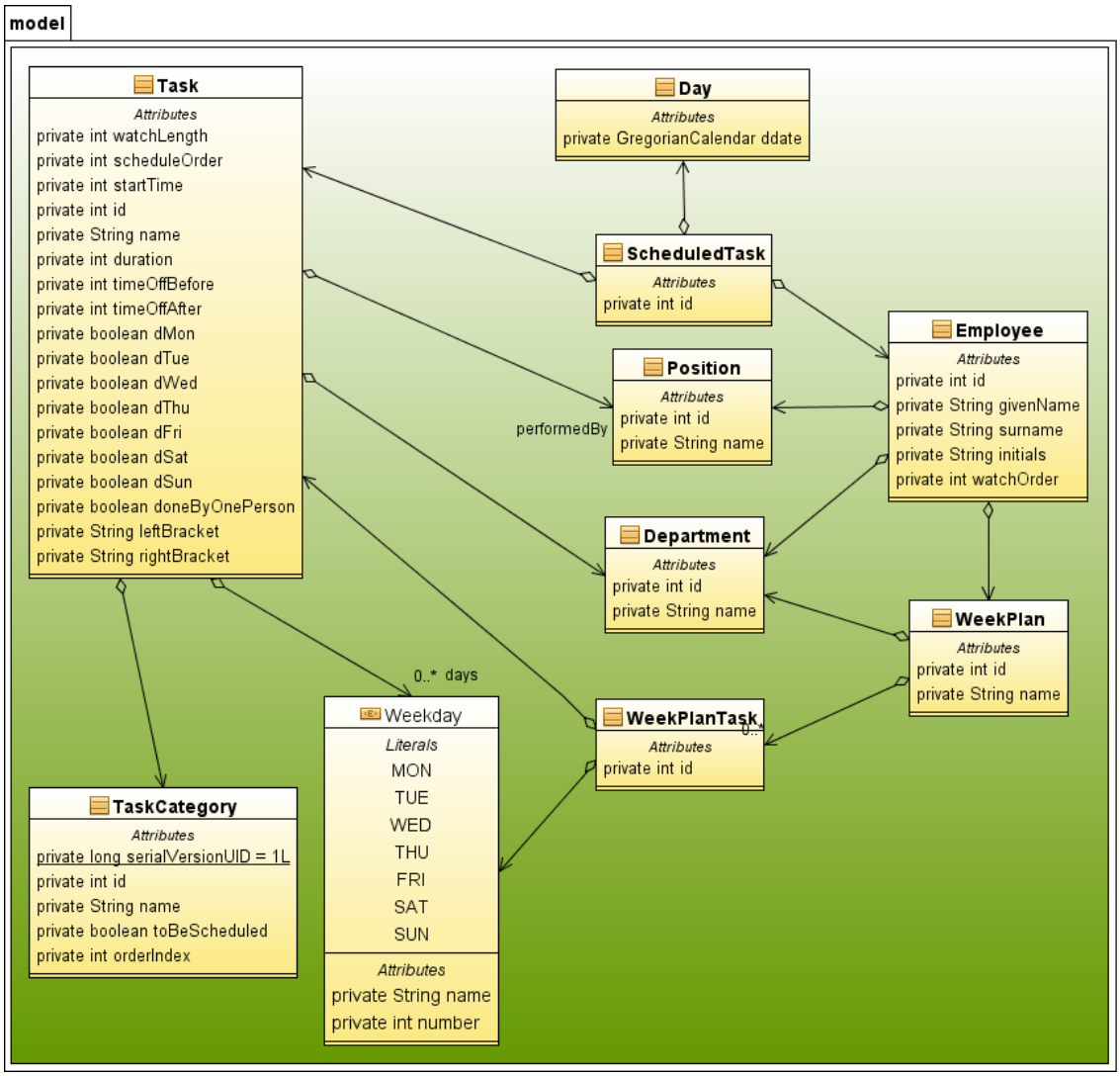

Figure 9.4: Class diagram: model package

9.3.2 Persistence

The persistence package is rather small, containing only one class. This is shown in Figure 9.5 This simply sets up the Hibernate `SessionFactory`, and keeps track of existing sessions. Each logged in user will have one session assigned, identified by the unique session-ID of his session. This class reads the `hibernate.cfg.xml` file, specifying which classes are to be persisted, database connection settings, and other Hibernate specific settings. This class also sees to that the Database scheme is correct, and will update it to suit the program if not. This means that Khronos can be deployed with a completely empty database. Khronos then creates the tables it needs, and sets up the relations between these.

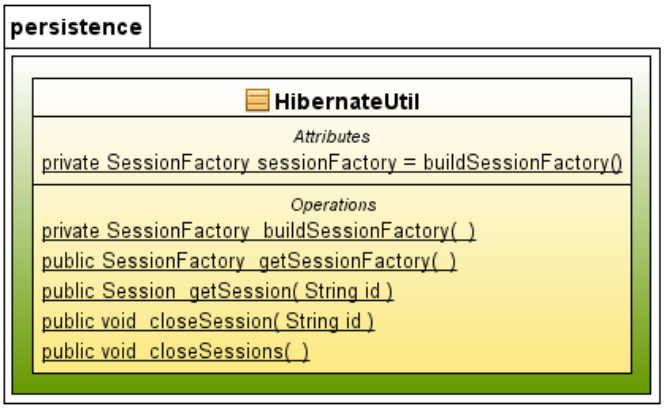

Figure 9.5: Class diagram: persistence package

9.3.3 Scheduler

The scheduler package contains the classes associated with the scheduling itself. The class diagram is shown in Figure 9.6.

The `Planner` class contains the scheduling algorithm. To get a `Schedule` for a period, one simply creates a `Planner` object and calls its plan method, which takes a start day and an end day as its parameters. Some convenience methods, such as checking whether an employee has a time slot free, was implemented in the `Schedule` class.

The planner works in two passes. First, it schedules the shift rotation for individual tasks that are shift scheduled, in an order that takes into consideration task interdependencies, which must be describable by a directed acyclic graph / forest.

After the first scheduling pass, the fixed duties are scheduled for each employee if they are not blocked by the watch rotation.

Most of the complexity lies in the watch rotation and ordering, and some of this has work has been given to the system user, as the user has to supply the schedule ordering for the tasks. If the user does not supply dependency information, tasks are assumed to not be able to be scheduled independently.

The system will create a watch rotation if the user does not supply a preferred ordering.

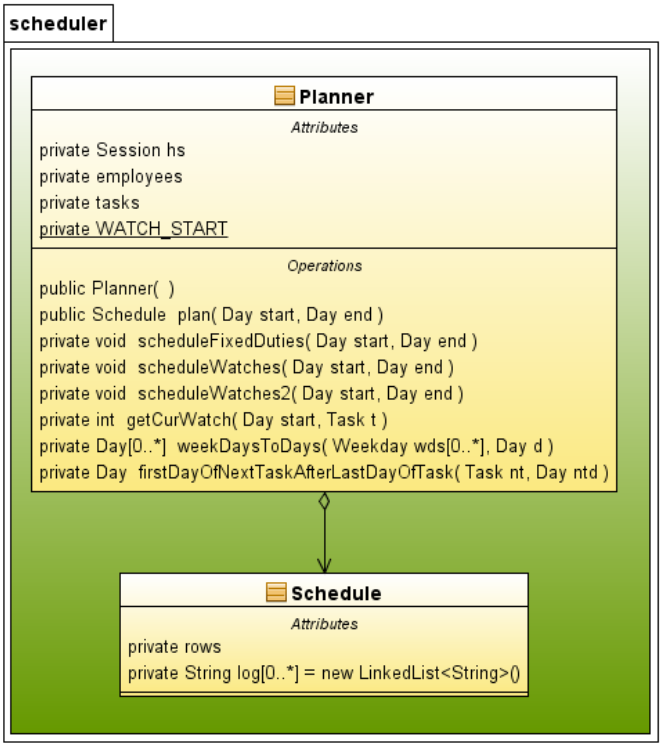
scheduler
Planner
Attributes
private Session hs
private employees
private tasks
private WATCH_START
Operations
public Planner( )
public Schedule plan(Day start, Day end)
private void scheduleFixedDuties(Day start, Day end)
private void scheduleWatches(Day start, Day end)
private void scheduleWatches2(Day start, Day end)
private int getCurWatch(Day start, Task t)
private Day[0..*] weekDaysToDays(Weekday wds[0..*], Day d)
private Day firstDayOfNextTaskAfterLastDayOfTask(Task nt, Day ntd)
Schedule
Attributes
private rows
private String log[0..*] = new LinkedList<String>()

Figure 9.6: Class diagram: scheduler package

9.3.4 Servlets

This package contains the servlets. This is shown in Figure 9.7. Servlets are classes that extend `javax.servlet.http.HttpServlet`, and that have methods for handling HTTP requests. The servlets handle the general logic in the web application and do the data processing, before forwarding the requests to the JSP motor which renders JSP files with the provided data.

`KhronosServlet` is an abstract class, which extends the class `HttpServlet`. All the other servlets extend `KhronosServlet`. This way, `KhronosServlet` defines common behavior between the different servlets. This includes forwarding to other URLs, initiating sessions, checking access levels, and ordering data tables based on user input.

`IndexServlet` simply shows the front page of the web application. It is also responsible for logging users out of the system.

`LoginServlet` handles logging users in to the application. If called with a GET request, it checks if the user is already logged in, by calling `getLoggedInUser()`. If this returns `null`, the user is not logged in, and a username/password form is shown. When this is submitted, the new request is posted to the new servlet, this time with a POST request. This initiates validating the credentials, logging the user in if he provided valid credentials. This is then stored in the `HttpSession`, making it available to other parts of the application. If a user is not logged in, and tries to access a protected page, he will be forwarded to this servlet.

`TaskCategoryServlet`, `TaskServlet`, `PositionServlet`, `DepartmentServlet` and `EmployeeServlet` allow showing, editing and adding related objects. These are described in detail in Section 9.3.1.

`WeekPlanServlet` lets the user define weekly plans to be followed by specific employees.

`ShowPlanServlet` lets the user display the plan for a specified period.

`MakePlanServlet` lets the schedule master assign employees to tasks, generating schedules based on input limitations, and change scheduled plans.

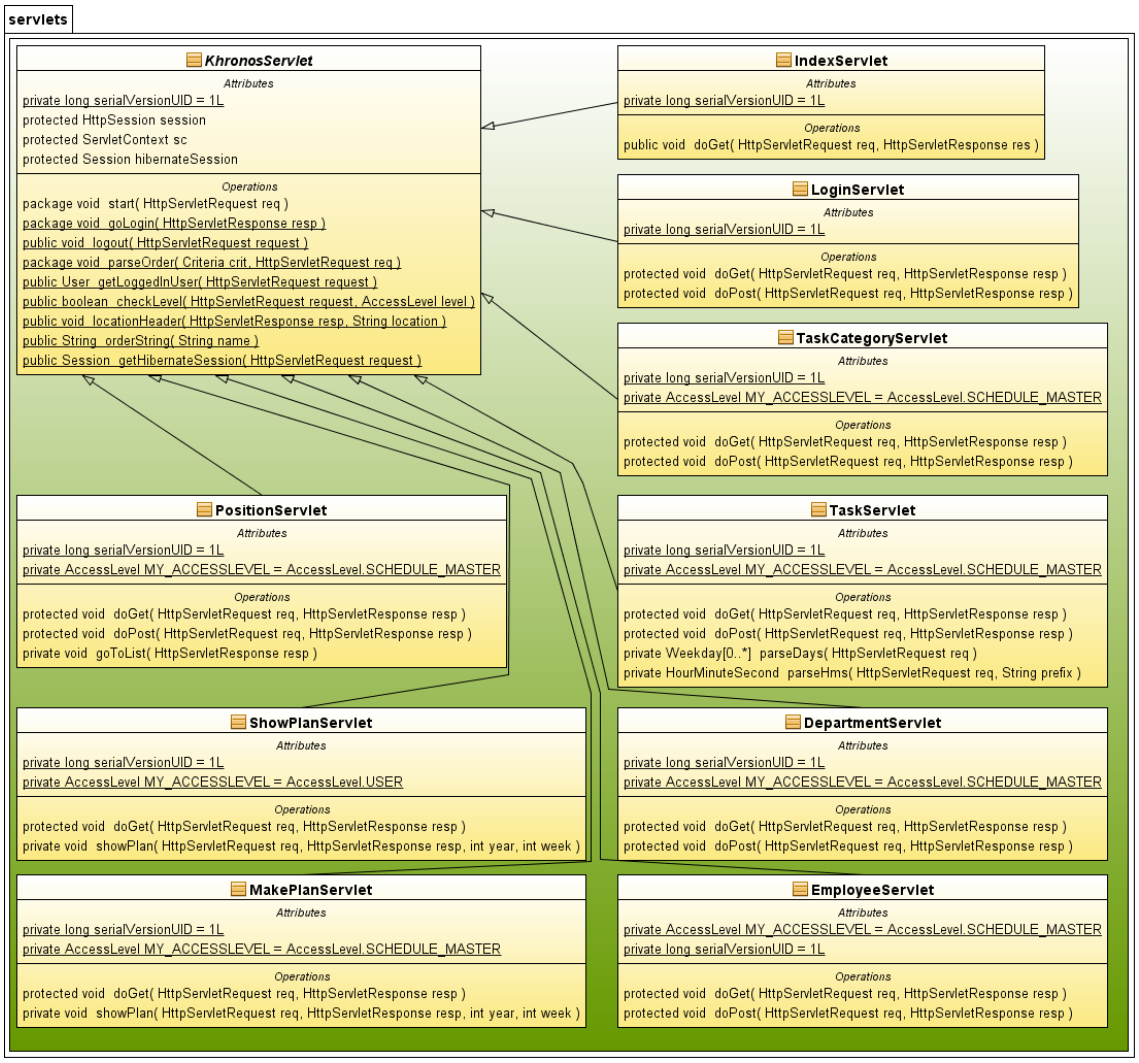
servlets
KhronosServlet
Attributes
private long serialVersionUID = 1L
protected HttpSession session
protected ServletContext sc
protected Session hibernateSession
Operations
package void start(HttpServletRequest req)
package void goLogin(HttpServletResponse resp)
public void logout(HttpServletRequest request)
package void parseOrder(Criteria crit, HttpServletRequest req)
public User getLoggedInUser(HttpServletRequest request)
public boolean checkLevel(HttpServletRequest request, AccessLevel level)
public void locationHeader(HttpServletResponse resp, String location)
public String orderString(String name)
public Session getHibernateSession(HttpServletRequest request)
IndexServlet
Attributes
private long serialVersionUID = 1L
Operations
public void doGet(HttpServletRequest req, HttpServletResponse res)
LoginServlet
Attributes
private long serialVersionUID = 1L
Operations
protected void doGet(HttpServletRequest req, HttpServletResponse resp)
protected void doPost(HttpServletRequest req, HttpServletResponse resp)
TaskCategoryServlet
Attributes
private long serialVersionUID = 1L
private AccessLevel MY_ACCESSLEVEL = AccessLevel.SCHEDULE_MASTER
Operations
protected void doGet(HttpServletRequest req, HttpServletResponse resp)
protected void doPost(HttpServletRequest req, HttpServletResponse resp)
PositionServlet
Attributes
private long serialVersionUID = 1L
private AccessLevel MY_ACCESSLEVEL = AccessLevel.SCHEDULE_MASTER
Operations
protected void doGet(HttpServletRequest req, HttpServletResponse resp)
protected void doPost(HttpServletRequest req, HttpServletResponse resp)
private void goToList(HttpServletResponse resp)
TaskServlet
Attributes
private long serialVersionUID = 1L
private AccessLevel MY_ACCESSLEVEL = AccessLevel.SCHEDULE_MASTER
Operations
protected void doGet(HttpServletRequest req, HttpServletResponse resp)
protected void doPost(HttpServletRequest req, HttpServletResponse resp)
private Weekday[0..*] parseDays(HttpServletRequest req)
private HourMinuteSecond parseHms(HttpServletRequest req, String prefix)
ShowPlanServlet
Attributes
private long serialVersionUID = 1L
private AccessLevel MY_ACCESSLEVEL = AccessLevel.USER
Operations
protected void doGet(HttpServletRequest req, HttpServletResponse resp)
private void showPlan(HttpServletRequest req, HttpServletResponse resp, int year, int week)
DepartmentServlet
Attributes
private long serialVersionUID = 1L
private AccessLevel MY_ACCESSLEVEL = AccessLevel.SCHEDULE_MASTER
Operations
protected void doGet(HttpServletRequest req, HttpServletResponse resp)
protected void doPost(HttpServletRequest req, HttpServletResponse resp)
MakePlanServlet
Attributes
private long serialVersionUID = 1L
private AccessLevel MY_ACCESSLEVEL = AccessLevel.SCHEDULE_MASTER
Operations
protected void doGet(HttpServletRequest req, HttpServletResponse resp)
private void showPlan(HttpServletRequest req, HttpServletResponse resp, int year, int week)
EmployeeServlet
Attributes
private AccessLevel MY_ACCESSLEVEL = AccessLevel.SCHEDULE_MASTER
private long serialVersionUID = 1L
Operations
protected void doGet(HttpServletRequest req, HttpServletResponse resp)
protected void doPost(HttpServletRequest req, HttpServletResponse resp)

Figure 9.7: Class diagram: servlets package

9.3.5 Listeners

This package contains functions which are to be executed at specific times. The two classes are shown in Figure 9.8.

The `SessionListener` is called when HTTP sessions are created and destroyed, i.e. when the user arrives on the web page, and when he logs out. When a user first visits the web page, a Hibernate session is set up, and connected to this HTTP session. Other session variables are also set up, including `loggedInUser` (which is `null` when the user is not logged in). When the user logs out again, the session is destroyed, and the variables associated with this session are cleaned up. This also

means closing the Hibernate session.

The `ContextListener` is called when the context is initialized or destroyed. This means when the server is deployed or undeployed. When the server starts up, the `HibernateUtil` is loaded, calling `buildSessionFactory()`. By doing this, the database is ready and updated by the time the web server is up and running. When the server is shut down, all existing sessions, and connections to the database, are closed.

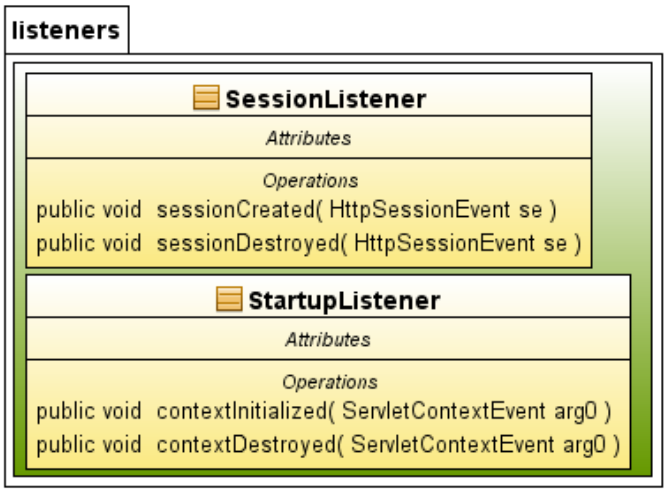

Figure 9.8: Class diagram: listeners package

9.3.6 Authentication

The authentication package handles authentication and authorization, i.e. validating user credentials, and identifying a logged in user and his access level. It is shown in Figure 9.9. The class `Authentication` has a static method to check if a given username/password is valid. If it validates, a matching `User` object is returned. Otherwise, `null` is returned.

A `User` is identified by a username, and has a specified `AccessLevel`. The two possible levels are `SCHEDULE_MASTER` and `USER`. The different servlets use these to check if a given user should have access to a given page.

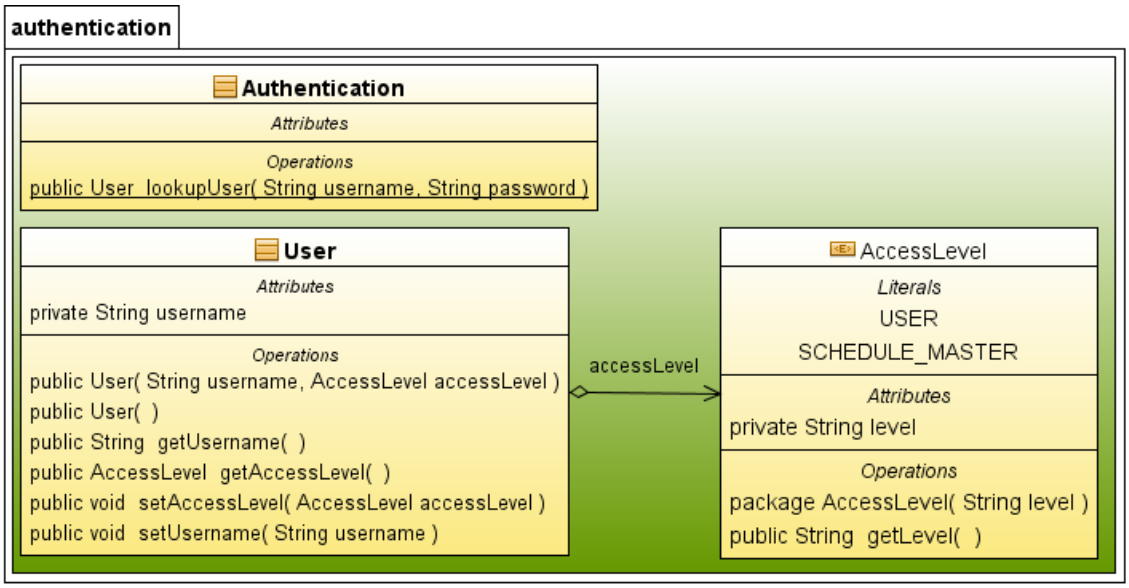

Figure 9.9: Class diagram: authentication package

9.3.7 Utilities

This package is meant to collect helping methods used by other packages. It is shown in Figure 9.10.

The class `HourMinuteSecond` is used to convert between time representations. In the database, all times of day are specified by seconds after midnight. This makes it easier to calculate duration of tasks, end time of a task, and enables tasks to start one day, and end the next. This class is therefore used for converting between this representation and a user friendly hours:minutes:seconds representation. This could have been done by using `java.util.Date`, but our approach is more lightweight, and does not combine date and time.

`KhronosMonthCalendar` is used for generating nice calendars in HTML. It extends `java.util.GregorianCalendar`, which has the needed logic for calculating dates, getting correct week numbers, weekdays, and dates in a month. If the default constructor is called, it will show the current month or year. The current date will be highlighted, and it contains links for choosing given time intervals (week, month).

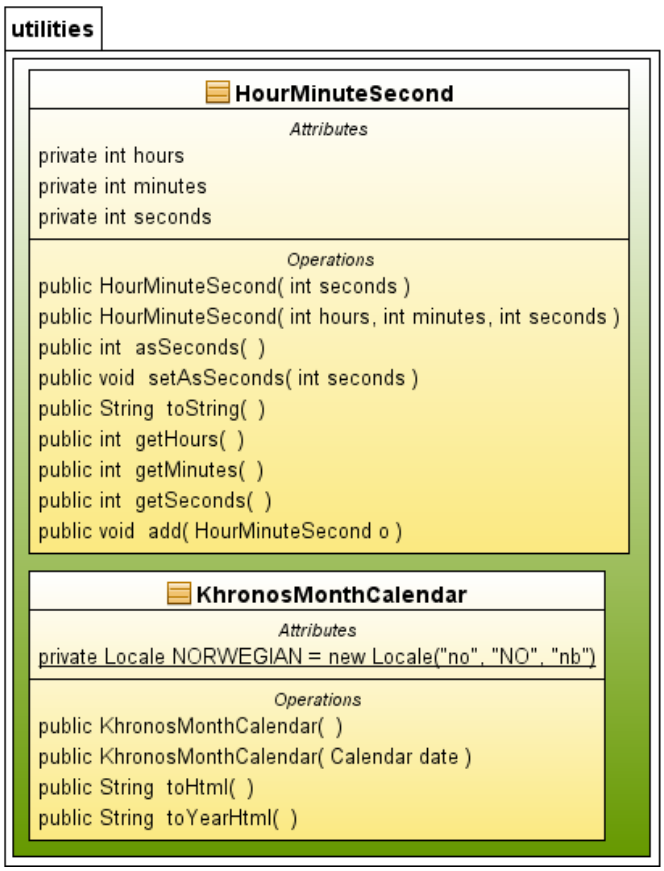

Figure 9.10: Class diagram: utilities package

9.4 JSP

As described in the previous section, JSP generates the HTML output. This sequence was shown in Figure 9.2. A servlet can pass objects to JSP by adding them as attributes to the request before passing it on to JSP. This enables us to use the built-in methods in the classes, as well as iterating over lists of objects. This is an easy way of implementing MVC, separating view from business logic.

9.5 Sequence diagrams

In this section, we will show some more sequence diagrams to explain how parts of the application work together.

Figure 9.2 showed the general sequence of the web app. All these parts are involved when accessing any part of the web app. To keep the sequence diagrams cleaner and tidier, they are omitted in some of the other diagrams.

The first diagram we show describes logging in to the server. This is shown in Figure 9.11. When a user tries to access a protected page, the servlet will call `getLoggedInUser()`. This method returns `null` if the user is not logged in. In the `LoginServlet`, this triggers showing the login form. When this form is submitted, the static method `Authentication.lookupUser(username, password)` is called.

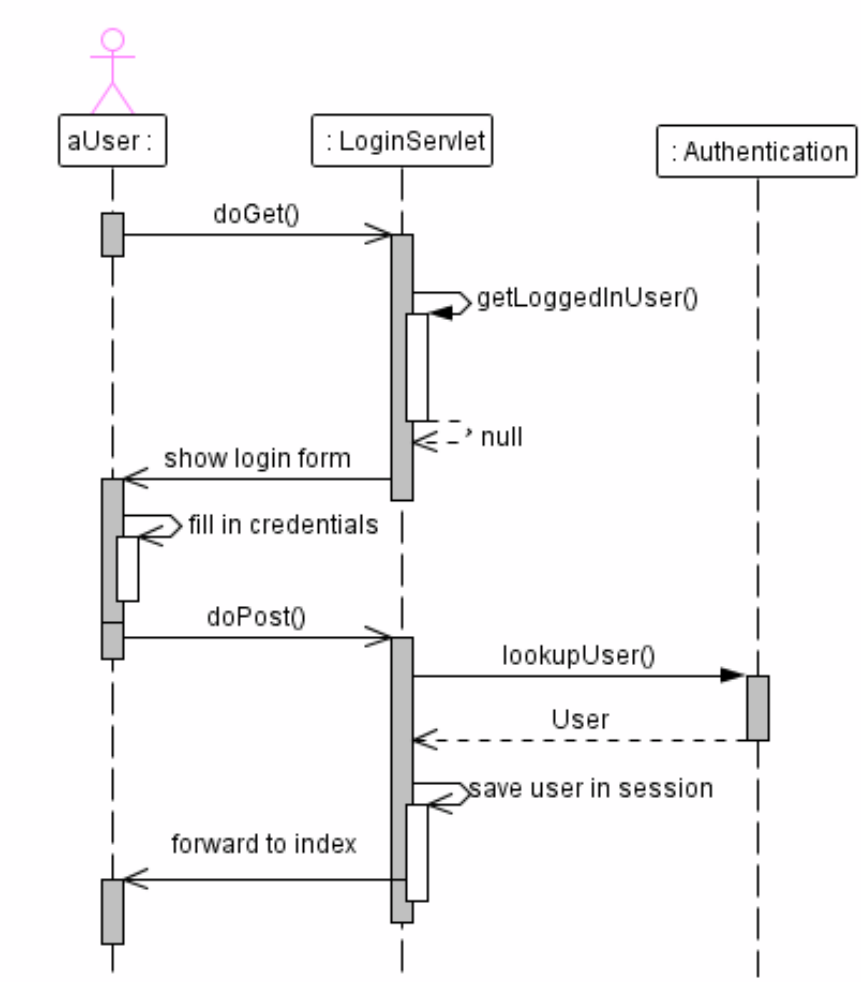

Figure 9.11: Sequence diagram: logging in

This returns a matching User object, which is then associated to the session. This way, all other pages can look for this object to see if a user is logged in. After the user is logged in, he is forwarded to the index.

Figure 9.12 shows the listing of employees. The interesting part in this diagram is what is related to the `Query` class. This is part of Hibernate, and lets you select data from the database. When you call `Query.list()`, a list of objects is returned. These are now in a persisted state, so that if you change them, you only have to flush the Hibernate session to update the state in the database. In this sequence diagram, however, the list of employees is just saved as an attribute in the request, which is then forwarded to a JSP page. This then iterates over the objects, and generates HTML for displaying them in an HTML table.

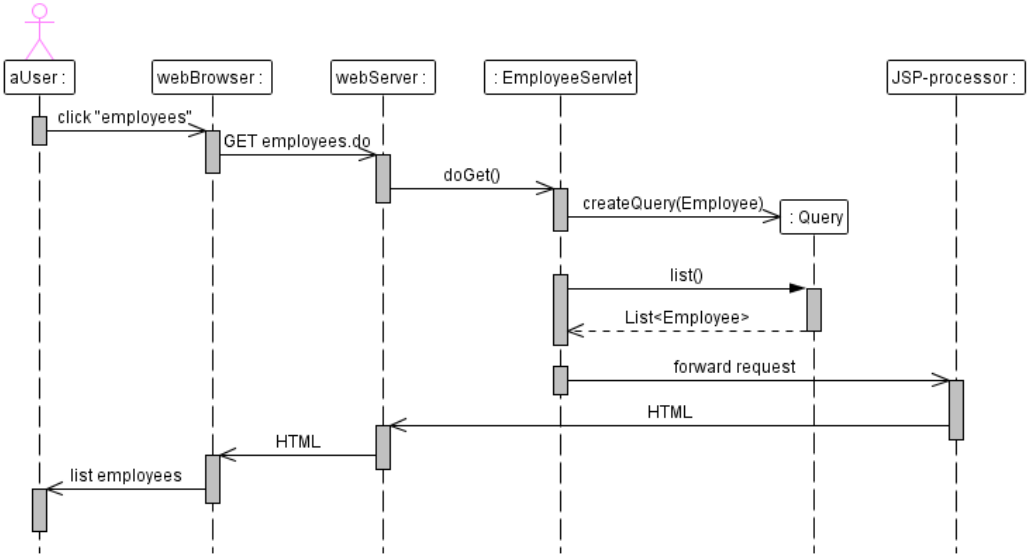

Figure 9.12: Sequence diagram: show employees

CHAPTER 10

Evaluation

This chapter will evaluate different aspects of our project in *TDT4290 Customer Driven Project*. The purpose of this chapter is to discuss our thoughts on how we performed compared to the expectations we had in the beginning of the project. We will, among other things, discuss the group dynamics, the choices made in the process and tools used. We will also provide an evaluation of the final result and possible extensions should the program be developed further.

The benefit of this evaluation is for the group to reflect back on the project and learn from both the good and the bad things that occurred, and also to discuss the consequences this had on the project.

The first section is about the process. It evaluates the effort the group put into the project and how we performed. In the second section we evaluate our experience with the different tools and frameworks we used. Third, we we evaluate the product. Which requirements were finished, interaction with the customer regarding their problem and possible extensions of the program should it be developed further in the future.

10.1 Process

This section will evaluate the group dynamics and the development method and how this affected the process.

10.1.1 Teamwork

The group was randomly put together by five persons, each with different personalities and interests. Thus, we could not expect a perfect atmosphere, but fortunately it was no problem. The group has functioned well together and offered each other help when needed. There were no conflicts, only constructive discussions. The overall teamwork and progression of the project was acceptable.

During the project we had too little focus on documentation. This resulted in a lot of the documentation being done after the associated implementation. We should have been more strict about switching between the two, as it is easier to have in mind what to write while you implement, instead of afterwards.

10.1.2 Communication

Most of the communication within the group was done orally. Mostly because of our agreement of always sitting in the same work area from Tuesday to Friday outside other lectures or assignments. This turned out to be a good rule. It was never difficult to get help from the rest of the group, and it was easy to coordinate the work. One problem was the fact that most of us had completely different schedules, so most often there was a person missing. There were a few situations where we would have benefited from having the entire group present, but there was nothing we could have done with the matter though, and fortunately it did not affect us too much.

One idea that might had helped us was more communication with the other groups that took this course. Although the tasks were different, exchanging ideas and experience on group dynamics and processes could have affected us in a positive way.

10.1.3 Software Development Method

The chosen software development method used had a large impact on how we worked. Read more in Section 10.2.1 for our experience in using Scrum.

10.1.4 Time Estimation

In this project, the general idea was for each student should work about 24 hours every week. With 12 weeks that we scheduled for the project, and five members in our group, this added up to 1440 man hours to be spent. Since this number did not take into account the different projects with their respective workloads, and most importantly not the effectiveness, or lack thereof, in which individual people possess, we saw this more as a guideline. Reaching this number was not a goal in itself, but we were all motivated to work hard and put a lot of effort into the project.

We were originally just four members in the group, but one more joined us two weeks into the process. The rest of the group did not perform that well in the beginning as well, but this was not only our own fault. There was some confusion in the beginning about the task itself. Even though the customer did their best to explain their needs and help us out, they simply did not have time to meet us very often. The way the course had organized the initial phase was far from optimal as well. Before the first customer meeting the group members had just been informed about the other members and what task we had received. It would have been much better if the group had the possibility to meet each other and interpret the task content before this customer meeting.

There were also many hours lost due to illness in the group. One person was ill for a whole week, and it also happened every now and then that a person was sick for a day or two.

In the end, we ended up recording 1125 on the project. Divided by the group members and number of weeks, this ends up on 18.75 hours per week per person. Considering it would have been much higher if we had been five members from the beginning, and not lost so much due to sickness, we are satisfied with the effort we put into the project. The last eight weeks most of the group worked over 24

hours per week. The fact that we also had the prototype finished was a fact for encouragment.

10.1.5 Risk That Have Struck

Several risks are described in Appendix A. One risk that struck several times during the project was the first risk, illness or other unexpected absence. There was not much to do about this risk other than accept that people get sick, and just try to cope with it. The rest of the group managed to step in and do the work if it had priority most of the time. It was not always easy though, since there were dependencies between each others work.

The second risk occurred at certain stages in the project, but did not influence the final product. It only caused some minor delays that we quickly fixed once the other work was done.

Another risk we ran into was risk 5. On one of the first meetings, the two representatives from the customer showed some disagreement concerning the priorities of the requirements. This was easy to solve, as we told them we would be able to fulfill the preferred requirements from both of them. And we did.

The largest risk we encountered, as seen in the risk tables, was risk 8. The hospital had very strict rules about software on their systems, and we had to change our initial plans and make a web application. Fortunately, we contacted the right authorities early in the process concerning this issue. Had we waited just a week or two more, a lot of work hours would have been wasted.

As for the rest of the risks, we managed to avoid them. Communication was good both within the group and with the customer, and the development tools did not cause any problems worth mentioning.

10.1.6 Milestones

We had several milestones in the project. The planned date and the date we actually reached the milestone can be viewed in Table 10.1.

Planned	**Actual**	**Milestone**
25.09.2009	25.09.2009	End Sprint 1
28.09.2009	28.09.2009	Deliver report for read-through
09.10.2009	09.10.2009	End Sprint 2
23.10.2009	23.10.2009	End Sprint 3
23.10.2009	22.10.2009	Demonstration with customer
06.11.2009	06.11.2009	End sprint 4
11.11.2009	17.11.2009	Presentation and report ready
19.11.2009	19.11.2009	Final delivery and presentation

Table 10.1: Milestones

10.1.7 What We Did Well

Once we got started on the work, much effort was placed into it. The daily meetings and punishment system was efficient in making sure that the members kept working

throughout the project period. The choice of doing the majority of the work while together as a group at the university, rather than working individually at home or some other venue, was also a good one. By working in this manner, communication between the group members was made quite efficient.

The relationships between the various group members were also generally unstrained. Comments and suggestions were able to flow freely between the members. Discussions were kept at a factual level, and were resolved amicably.

Contact between the group and the customer was kept close throughout the project period. This resulted in the discovery of misunderstandings and missing requirements. Had these not been discovered before the project end, the system could have been severely less useable by the customer. It also resulted in shortening the process of gathering useful information, such as relevant test data, from the customer.

10.1.8 What We Did Not Do Well

While the group worked efficiently once work got under way, the startup of the project was notably slow. Few hours were spent by the members during the first two to three weeks, and a smaller proportion of the time was spent working together as a group, than during the rest of the project.

The group members also had limited experience with development projects of this kind. This resulted in inaccurate estimates of the time and effort necessary to complete the various tasks and objectives throughout the process. This again resulted in an unbalanced division of labor among the group members, as well as an unduly optimistic estimate of the total work load involved in this project. As such, the group was forced to skip implementation of certain optional features that had initially been planned.

10.1.9 What We Learned

Through trial and error, the group members gained valuable experience in work estimation. The group also gained familiarity with several tools and frameworks, such as the Tomcat web server and Hibernate. Experience with agile software development, in the form of Scrum, was also gained. All of the experiences above are valuable assets for future development projects.

Working in a small group environment also resulted in the members gaining experience when it comes to managing interpersonal connections with other group members. Stress and cooperative work like this, where the results of the individual members depend on the work of other members, can result in irritation between the members. This again can result in less efficient cooperation, and a poorer end product. Knowing how to avoid such a situation is valuable knowledge.

10.2 Tools and Frameworks

This section will describe how we experienced the different tools and frameworks we used in our project.

10.2.1 Scrum

There were many good reasons why we chose Scrum to be our development method. Changed or added requirements would not impact the process as much as it would with waterfall model, easier to monitor the progress the group was making and producing working code early was some of them. Also the fact that we would most likely be using agile methods in most future projects, since more and more companies jump on the agile method band wagon, was a strong encouragement to use it.

Looking back at how we performed, there were both positive and not so positive experiences with Scrum. First off, to learn about and to get a better understanding of the method, we needed to spend many hours to read up on it. In the beginning of the first sprint we found it hard to plan and generate tasks, and were unsure about the process. Rather than encouraging us, we started to question if we would benefit from it. Scrum seemed more of a burden than a blessing. It was hard for all of us to adapt to the strict rules, especially in the combination with VersionONE. The burn down chart is an important tool for monitoring the progress and how the real situation is compared to the planned, and this requires everybody to update their status every day. Since we had no formal protocol or rules for updating the chart, this turned out to be fairly easy to forget.

Another problem we faced was the combination of Scrum and writing the report. Scrum is not a document centered method, it is more focused on producing a product. Therefore there rose some confusion from time to time what we should do. On one hand we wanted to focus on the product and satisfy our customer, on the other hand we also felt the need to write a good report. It was not always easy to do both.

Throughout the process though, things fortunately changed. As we became more and more familiar with the method, the advantages of it started to shine through. The daily stand up meetings were mostly beneficial. They contributed to what they claim to do: checking and reflecting over the progress of the team, synchronizing the work and identifying obstacles early. The meetings were supposed to always be held at the same time, but this was not always the case. Scrum is very clear on that the meeting should be at fixed times and that the team should not wait for a member that is late. Sometimes though, we found it more beneficial to wait and have all present at the meeting. We decided that we should do what we thought is best for us. We should not follow a method just to follow it, but use the method to our best advantage.

All in all, the choice of Scrum turned out to be a big learning experience. The most valuable advantage turned out to be about changing of requirements, or the addition of new ones. Since our customer had any experience with software development, the requirements were primarily formed through communication with the group. As we produced code and faced crossroads of what we should approach next it was easier for the customer to understand our thoughts and questions. We also liked the close contact with the customer Scrum encourages, and we think that our customer and customers in general, really likes to see working code early on.

10.2.2 Database and Hibernate

Using Hibernate showed to save a lot of work. We changed the relationships between the classes several times throughout the project. Without Hibernate, we would have had to write SQL Queries rather manually, and update them whenever we changed something. We would also have had to define the database schemas manually, also with frequent changes.

As soon as the relations were described correctly for Hibernate, all this was abstracted away. By specifying relations to be navigable in both directions (one-to-many, many-to-one), we could fetch the associated data in both directions. An Employee contains information about which Department he works in, and the Department knows which Employees work in the Department. This also made the scheduling easier, as we could fetch entire collections from the database at one time.

10.2.3 VersionOne

VersionOne is a project planing tool designed for agile software development. We used this tool to plan out our sprints, write up tasks and monitor their progress. It provided automatic statistics, like the burndown charts which were used in our daily stand-up meetings. We tried to use this tool, but failed to use it correctly to get the maximum potential gain from it.

This is a tool that might be better suited for larger projects than ours, none of us had used this tool before and for the first sprint we might have divided the tasks unsuitably for being able to monitor our progress correctly. Our project included a lot of documentation/report writing and this planing tool is not suited for projects where this is fifty percent or more of the work. This made it hard to follow our progress and to get an accurate burn down chart. Since none of us had used this tool before, and some of us did not like using it, it also contributed to not getting the maximum gain that this tool can create.

The main problem is that the scrum artifacts are hidden behind a login-screen online. We were warned about this, as mentioned in the preliminary studies. Despite of this, we wanted to give it a try, as we did not have a fixed working place. After some weeks, however, the different groups settled, and the working place became fixed after all. We would rather try using the manual tracking process, with the storyboard on a physical wall. This way, everything is visible to everyone, all the time.

10.2.4 Balsamiq Mockups

This mockup tool turned out to be very easy to use. It had images that represented our ideas well, and the function to export and import XML text made it easy to use for more than one person. Making the mockups digitally was a safe way to make them understandable and consistent, which would not be easy for one without any experience in drawing by hand.

10.2.5 Integrated Development Enviroment (IDE)

Initially, our group used Eclipse because of being familiar with it from previous work. When we decided to develop Khronos as a web application, however, it became apparent that we would gain much by switching to NetBeans, because of its straight forward integration with the Tomcat application server and our database of choice, MySQL. Among other things, NetBeans can deploy web applications to Tomcat automatically, and trigger a reload of the server when updated code is available.

10.3 The Product

This section will focus on the product, mainly on the task itself, interaction with the customer and the final result.

10.3.1 The Customer

Today, the hospital staff are making schedules more or less by hand, and the result is far from easy to look at or understand. Our task was to make this scheduling problem easy to solve and make the result better than what they had before. We were in contact with two doctors who presented their problem to us. One of them continued to meet with us to supervise the progress, and help us with any questions we had. Since they are doctors, and do not have a technical background, we had to put some extra effort into communication to make them understand what we could and could not do, and what input we would need.

The customer representatives took steps to make themselves available to us for questions and input. This was of great help, as our initial understanding of the problem proved incomplete. Much e-mail communication and several meetings were needed for the group to gain a full understanding of the task.

10.3.2 The Task

The task, writing a flexible scheduler for the hospital, was quite interesting. Implementing a solution spanned a broad part of what we have learned so far at NTNU. Everything from object oriented programming, algorithms, database programming, software architecture, JSP/web programming and project time management and estimation came into play. The tasks of managing customer expectations and gathering requirements proved to be essential.

The task was in itself a perfect example of a problem that many consultancies face every day: solving a concrete problem for a customer with standard tools and technologies, with limited time to complete a solution.

All in all, we learned a lot and got much needed hands on experience, much thanks to our task being the way it was.

10.3.3 Requirements Solved

Tables 10.2 and 10.3 shows an overview over the requirements and if they were solved or not. We managed to satisfy almost all of them. All of the requirements

ID	Description	Priority	Solved
F01	The user can define a plan.	High	Yes
F02	The user can make changes in a generated plan.	High	Yes
F03	The user can attach two doctors for a given period.	Medium	No
F04	The user can define a doctor in the system.	High	Yes
F05	The user can set availability for a doctor for a period of time.	Low	Yes
F06	The user can define rooms/departments.	High	Yes
F07	The user can define tasks.	High	Yes
F08	The user can assign a doctor to a fixed task.	Medium	Yes
F09	The user can choose to view the plan for everyone or just himself.	Medium	No
F10	The user can choose to view the plan for different time scopes; day, week, month, etc.	Medium	Yes
F11	The user can print the schedule.	High	Yes
F12	The user can log in	High	Yes
F13	The user can log out	High	Yes
F14	The user should be able to export data to the iCal format.	Low	No

Table 10.2: Result: Functional requirements

with high priority were solved.

F03, attaching two doctors for a given period, was not directly solved. After some discussions, we found out that this relationship does not really exist. When a junior doctor is to follow a supervising senior doctor, they are scheduled with similar weekly plans. Therefore, this requirement was considered irrelevant, and not solved.

F09, viewing a personal plan, was not completed due to time constraints. This was a feature we wanted to add, but that the customer did not request. As this was not a vital requirement, but a nice-to-have usability requirement, it was down-prioritized for the benefit of other features.

F14, exporting to iCal was also prioritized lower. This was a feature originally mentioned as a nice-to-have feature. After some research, we found out that it would be a demanding task to implement this, as we would also have to consider synchronization between the client program and Khronos. We made it clear to the customer that we would probably not be able to solve this request, but we put it in the requirement specification in case.

NF05, undo functionality, was not implemented. This was a requirement that we set ourselves, because of usability concerns. One principle is that the user should be able to undo actions, so that unintended changes could be reverted. As this would have introduced quite an overhead of tracking a history of changes, we made it harder to make major unintended changes, by introducing confirm dialogs.

10.3.4 The Result

We have shown that a computer program like Khronos can be a helpful addition for the different departments in the hospital. We have only collaborated with one

ID	Description	Priority	Solved
NF01	There must exist a friendly user manual and a proper documentation of the system design	High	Yes
NF02	The schedule must be set up within reasonable time after specifying all constraints.	Low	Yes
NF03	It should be easy for the user to insert correct input	Medium	Yes
NF04	The application must be simple and easy to understand	High	Yes
NF05	The program should allow undo actions	Low	No
NF06	The program must not require external components under proprietary licences	High	Yes
NF07	The application must distribute the "on-call"-hours fairly, depending on the working hours.	High	Yes
NF08	The application must make sure that all the tasks of the week are covered and notify the user if there is a task that has not been covered or if a employee is double booked.	High	Yes
NF09	The application should display a schedule in a printable format.	High	Yes
NF10	The application must discern between the different working hours of the specialists and the rest.	High	Yes
NF11	The application must be able to discern between the different tasks, as some must be done several times a week while some only once a week.	High	Yes

Table 10.3: Result: Non-functional requirements

single department, so we do not know how the different departments of the hospital distribute their shifts. Because of this, we made the system rather flexible, allowing the user to define domain, instead of hard-coding it by making separate classes for the different positions.

We think that our program could prove an efficient tool for our customer, the ENT department.

10.3.5 Further improvements

To make the user interface more efficient, editing plans could be simpler. This could be done by enabling drag-and-drop for the different items in a plan. This way, a list of unused employees could be shown on the right of the plan, and the schedule master would then drag the available employees to their right tasks. Also, copying parts of periods could be a practical addition.

In our program, absence has to be defined day by day. This means that specifying that an employee is not present for an extended period of time, could be a long and repetitive task. This could be improved by allowing the schedule master to specify absence from a given date, to a given date.

One requirement that we did not implement was the iCal support. The customer signalized that synchronization with calendar applications, like MS Outlook, would increase usability a lot. Therefore, this should be addressed if the system is to be expanded. Another unfinished requirement was NF05, the one regarding undo actions. Implementing this would raise the usability of the program quite a bit.

The authentication / authorization is today only split in two users, who have pre-defined access levels. As the employees might want to exchange shifts, and do other changes to the plan (which then again have to be approved), personal logins could be implemented. The employee could register changes in the plan, which are then shown to the schedule master, who has to approve the changes. This way, an employee could log in and register his wishes for vacations a long time in advance, enabling the schedule master to plan accordingly. Today, vacations are hard to predict, as no-one knows how the plan is going to look in the possible vacation weeks.

As some tasks in the hospital are more important than others, shift scheduling could be improved. Today, shifts are assigned in a specific order, so that an assistant doctor is put to work a night shift when it is his turn, instead of considering what his work day is like. This means that assistant doctors could miss out on more operation days than others, if they are unlucky. This could be improved by assigning utility values to performing specific tasks. We did mention this as a possibility to one of the customer representatives. She was positive to this possibility, but was concerned that people who are used to the old system would be confused, and disagree with that new way of solving the task. She made it clear that the system should at least support the old way of scheduling tasks, and we therefore prioritized solving the task at hand.

The system could display warnings to the user doing the scheduling if it is unable to schedule anyone to do a task. This functionality already has support in the Planner, but requires some modifications to the GUI and persistance code.

Specifiying inter-task dependencies for scheduling could be made more user

friendly, as this is in principle algorithmically simple, but GUI intensive.

10.4 Conclusion

Even though there was some initial confusion, we got to know the task better and better and we have a finished product that should be useful for the customer. It should greatly simplify the process of making the schedule, even though it is just a prototype. The testing did not reveal anything that would imply otherwise. The project is therefore tentatively considered a success. We also learned a massive amount of knowledge about teamwork, customer contact handling and software development in general. All in all the course has been a great experience for all the group members.

We are grateful for what the course has offered us. We were very satisfied with the customer. Even with their busy schedule they made an effort to aid us with all our questions.

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Appendices

APPENDIX A

Risk Analysis

This section contains the detailed risk tables which are summarized and explained in Section 2.2.

1	**Phase**	All
	Risk Factor	Illness or other unexpected absence
	Consequence	Delay, inability to finish some tasks, miss deadlines
	Proactive actions	Try to manage and organize the work so that the project progress is not dependent on one single group member.
	Reactive actions	The rest of the group will have to work extra to compensate or/and cut tasks that there's not enough time to finish
	Probability	4
	Damage	6
	Risk	24
	Responsible	Everyone

2	**Phase**	All
	Risk Factor	Too much to do in other subjects
	Consequence	Makes it harder for the group to work together and delays the progress of the project
	Proactive actions	Plan and organize the project so that we can cut out parts of the project
	Reactive actions	Cut out something that there's not enough time to finish
	Probability	6
	Damage	6
	Risk	36
	Responsible	Everyone

3	**Phase**	All
	Risk Factor	Lack of materials
	Consequence	Unable to have a meeting because we don't have a meeting room available
	Proactive actions	Start planing and booking meetings early so that there's plenty of time to get a room
	Reactive actions	Make a new meeting as soon as possible or make the next meeting longer so to cover the agendas for both meetings
	Probability	2
	Damage	4
	Risk	8
	Responsible	Everyone

4	**Phase**	All
	Risk Factor	Internal conflicts
	Consequence	Makes it difficult to cooperate
	Proactive actions	Try to show consideration for others. Be flexible within reason
	Reactive actions	Resolve conflicts by discussion. If this does not succeed and the conflict threatens the project, seek external guidance. Make a decision based on democracy, chance (coin flip), group leader/scrum-master
	Probability	2
	Damage	6
	Risk	12
	Responsible	Everyone

5	**Phase**	All
	Risk Factor	External conflicts
	Consequence	Make it difficult to have a good and productive relationship with the client
	Proactive actions	Plan to have a lot of communication with the customer, meetings, status updates, invite the customer to come to scrum meetings etc.
	Reactive actions	Resolve conflicts by discussion. Have a meeting with the client and everyone else involved and try to solve the problem
	Probability	2
	Damage	8
	Risk	16
	Responsible	Customer contact

6	**Phase**	All
	Risk Factor	Internal misunderstandings
	Consequence	Group members work on the same task with out knowing it or/and another task gets forgotten
	Proactive actions	Make sure that the group talks to each other, work together, stand-up meetings. Assign any tickets you plan on dealing with to yourself before you start working on them.
	Reactive actions	Learn from the mistake that has been done and make sure that it does not happen again. Compare what the group members have done and select the better result, or merge
	Probability	2
	Damage	4
	Risk	8
	Responsible	Everyone

7	**Phase**	All
	Risk Factor	External misunderstandings
	Consequence	Misunderstand what the customer means and wants
	Proactive actions	Have regular meetings and update the client often on what the group is doing and how the project is progressing
	Reactive actions	Have meeting and clarify any misunderstandings as fast as possible, find out the cause of the misunderstanding and prevent reoccurence
	Probability	3
	Damage	7
	Risk	21
	Responsible	Everyone

8	**Phase**	All
	Risk Factor	Security problems
	Consequence	Not allowed to run any programs on their systems
	Proactive actions	Contact the customer system admins and find out early which options we have
	Reactive actions	
	Probability	6
	Damage	8
	Risk	48
	Responsible	System architects

9	**Phase**	All
	Risk Factor	Don't know how to use development tools
	Consequence	We have to use alot of time to learn how to use them
	Proactive actions	Try to figure out early what we need to use, try to plan so that we only need the tools we know
	Reactive actions	One or two group members can learn how to use the tool and then teach it on to the other group members if necessary
	Probability	8
	Damage	6
	Risk	48
	Responsible	Everyone

APPENDIX B

Version control – procedures

To keep track of changes in code and documents and allow several users to edit at the same time, we are using Subversion. This appendix will give some information about how to connect to the repository, as well as guidelines for usage.

Setting up Subversion

Easy way: use Tortoise SVN[1]. Repository is located at `http://basar.idi.ntnu.no/svn/kproh2009g03`.

Setting up repository using Tortoise SVN in Windows

1. Create a folder, where you want the project files to be located.
2. Right click inside this folder, and select SVN Checkout.
3. The repository URL is `http://basar.idi.ntnu.no/svn/kproh2009g03`.

Setting up Subclipse in Eclipse

1. Install Eclipse[2]
2. Install Subclipse in Eclipse.
   (a) Help → Install new Software...
   (b) Work with: `http://subclipse.tigris.org/update_1.6.x`
   (c) Select required (or all) packages, and install them.
3. Checkout repository
   (a) New : Checkout projects from SVN

[1] `http://tortoisesvn.net/downloads`
[2] `http://www.eclipse.org/downloads/download.php?file=/technology/epp/downloads/release/galileo/R/eclipse-jee-galileo-win32.zip`

   (b) Create a new Repository location
   (c) URL: `http://basar.idi.ntnu.no/svn/kproh2009g03/code`
   (d) Complete wizard, and you are ready

4. You can now SVN update, commit, etc.

5. If you want to commit new files (that are not yet under version control), you will have to add them before committing.

APPENDIX C

User Manual (Norwegian)

This Appendix is in Norwegian, as one of the requirements states that the interface should be provided in Norwegian.

Bruk, Administrator

Denne seksjonen inneholder hva du skal og kan gjøre, logget inn som administrator. Brukernavn og passord er i utgangspunktet henholdsvis *master* og *master*.

Oppsett

Dette er hva som må gjøres første gang du bruker systemet etter installasjon, før du kan begynne med selve planleggingen. Merk at alt du gjør her, vil i ettertid være både modifiserbart og reversibelt.

Avdelinger

Gå til "Avdelinger" i menyen til venstre i nettleseren. Denne siden vil vise deg, og la deg redigere, hvilke avdelinger som eksisterer i systemet. Velg "Legg til avdeling", skriv inn avdelingsnavnet, og velg "Lagre", se Fig C.1. Gjenta for alle avdelinger du vil planlegge for.

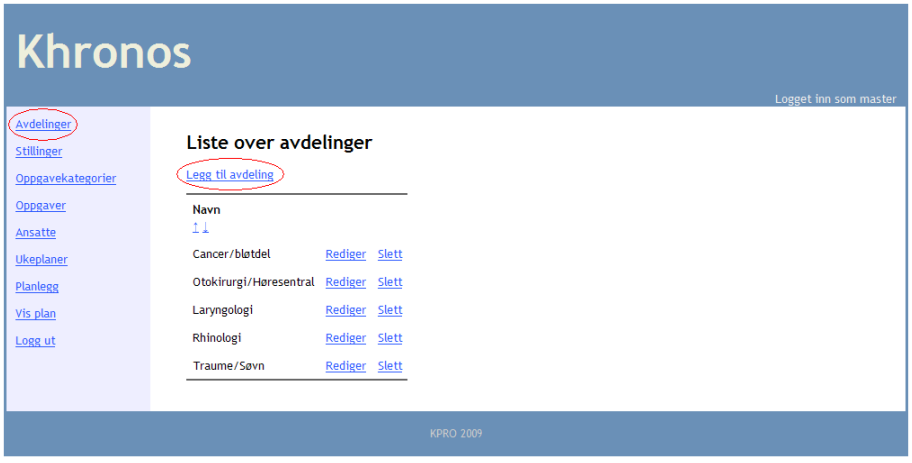

Figure C.1: Legg til avdeling

Stillinger

Gå til "Stillinger" i menyen. Denne siden viser deg, og lar deg redigere, alle stillinger som skal eksistere i systemet. For hver stilling du skal operere med, velg "Legg til stilling", skriv inn navnet i feltet, og trykk lagre, se Fig C.2.

Figure C.2: Legg til stilling

Oppgavekategorier

Gå til "Oppgavekategorier" i menyen til venstre. Denne siden vil vise deg, og la deg redigere, hvilke overordnede oppgavekategorier som eksisterer i systemet. Alle oppgaver du definerer senere for planleggingen vil være ordnet under en av disse kategoriene. Eksempler kan være primærvakt, fravær eller operasjon. For å legge til nye kategorier, velger du "Legg til kategori", se Fig C.3. Skriv så inn navnet på kategorien, sortering, og om den skal fordeles. En kategori som skal *fordeles* vil automatisk bli fylt av systemet når du ber det planlegge. De andre kategoriene må enten fylles manuelt, eller settes som en del av en ukeplan. *Sortering* bestemmer rekkefølgen kolonnene for oppgavene havner i på planen. Velg så "Lagre". Gjør dette for alle kategorier du vil ha i systemet.

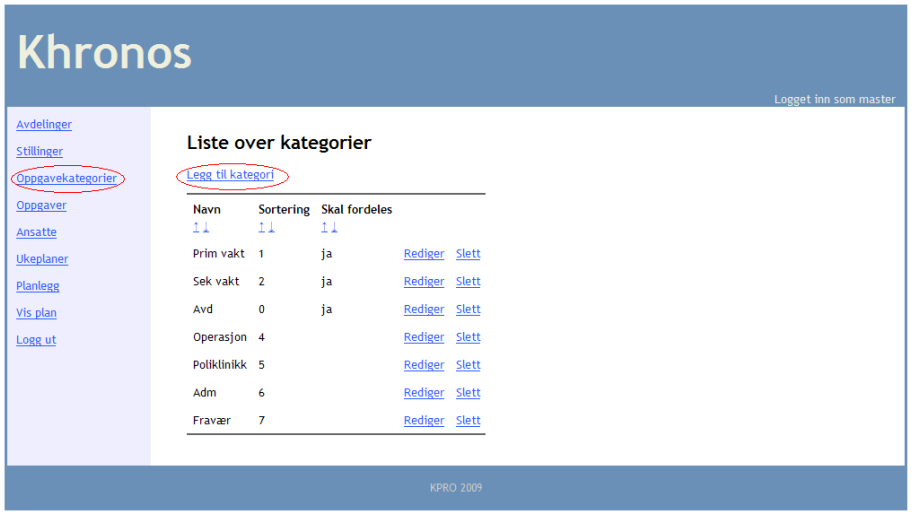

Figure C.3: Legg til oppgavekategori

Oppgavekategorier er i dette systemet også ment å brukes for å organisere fravær. Dette gjøres da ved å sette opp en kategori med et navn som "Fravær" eller liknende. Denne kategorien må da ikke settes til å fordeles automatisk, men manuelt ved fravær.

Oppgaver

Gå til "Oppgaver" i menyen. Her defineres og redigeres alle oppgaver som skal være med i planen. For hver oppgave, velg "Legg til oppgave", fyll inn feltene og trykk "Lagre". Etterfølgende oppgave brukes der det finnes en annen oppgave som naturlig følger oppgaven du er i ferd med å definere, i den form at en person som utfører denne oppgave, også skal utføre den etterfølgende oppgave ved første leilighet. "Gjøres av en person" brukes der en oppgave som skal utføres på flere dager i uka, skal utføres av samme personen alle dagene. Se Fig C.4. "Start" er oppgavens starttidspunkt. "Fri før" og "Fri etter" brukes der personen som skal utføre oppgaven er nødt til å ha en viss periode fri før og/eller etter oppgaven. Er ikke dette nødvendig, settes bare 0. Ukedager definerer hvilke dager i uka oppgaven skal utføres. Skal oppgaven utføres til forskjellige tidspunkt på de forskjellige dagene, må separate oppgaver defineres for de forskjellige dagene. Paranteser brukes til å identifisere forskjellige oppgaver som tillhører samme oppgavekategori i den endelige planen. I planen vil oppgaven representeres med ¡parantes¿¡initialer på person som skal utføre den¿¡prantes slutt¿, i kollonnen til oppgavekategorien oppgaven tilhører. Sortering bestemmer rekefølgen oppgavene planlegges i. Oppgaver med lav verdi her, planlegges før oppgaver med høy verdi - dette for å ta hensyn til avhengigheter mellom oppgaver. Feltet lengde på periode angir hvor mange dager det går fra en person går på vakt med oppgaven til en annen person skal gå på vakt med oppgaven. Dette er informasjon planleggeren trenger for å kunne håndtere vaktsykler med forskjellig lengde for forskjellige oppgaver.

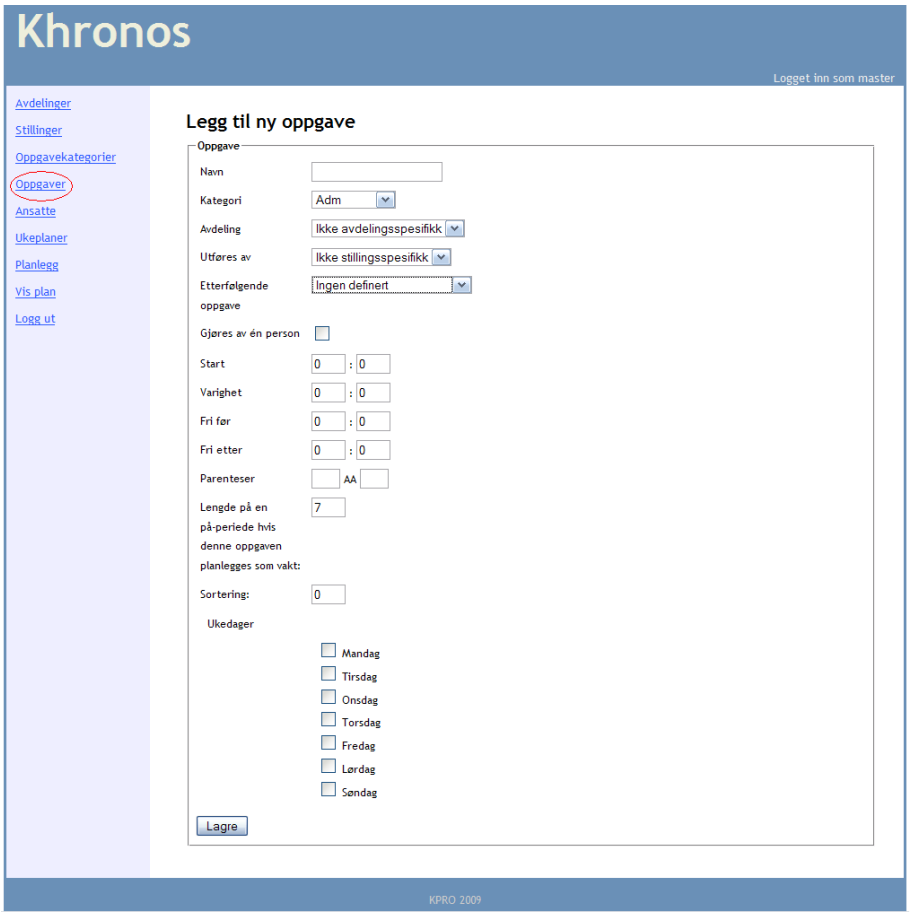

Figure C.4: Å definere en oppgave

Forskjellige typer fravær skal også opprettes her, under kategorien brukt for å representere fravær i "Oppgavekategorier".

Ukeplaner

Ukeplaner er planer du kan sette individuelle ansatte til å følge gjennom uka, og så planlegge resten av oppgavene rundt disse. For å lage en ukeplan, gå til "Ukeplaner" i menyen, velg "Legg til ukeplan", skriv inn navn, og velg eventuelt avdelingen denne planen skal tilhøre. Trykk "Lagre". Finn så planen i listen, og trykk "Rediger". Du kan nå definere oppgaver med tilhørende dager for ukeplanen, se Fig C.5.

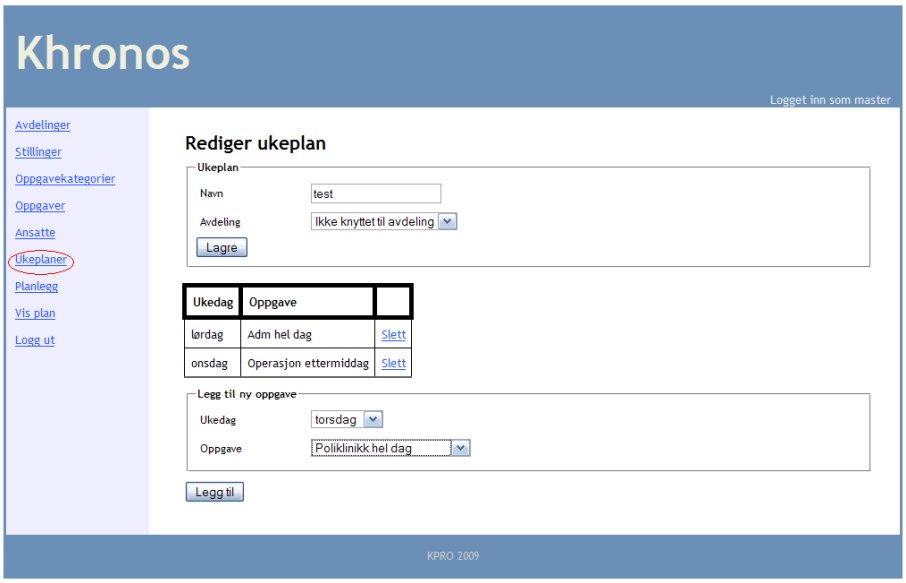

Figure C.5: Å redigere en ukeplan

Ansatte

Gå til "Ansatte" i menyen. Denne siden viser alle ansatte registrert i systemet med fornavn, etternavn, initsialer, vaktrekkefølge, stilling, avdeling og ukeplan. Velg "Legg til ansatt", fyll inn feltene, se Fig C.6, og trykk "Lagre". Ukeplan vil sette denne ansatte til å følge denne ukeplanen. Vaktrekkefølge brukes av systemet når det skal sette folk på de oppgavene som skal gå på rundgang gjennom planlagte perioder. De med lave verdier her vil settes opp på disse vaktene før de med høyere verdier. Gjenta for alle ansatte som skal være med i planer.

Figure C.6: Å definere en ansatt

Vanlig Bruk

Du vil nå kunne planlegge med de oppgaver, ansatte, stillinger, osv. du har satt opp under oppsettet. Hvis du vil endre noe av det, slette, eller legge inn nytt, er

alt dette fremdeles mulig med hhv. "Rediger", "Slett" og "Legg til", som er å finne under de relevante punktene i menyen til venstre.

Planlegg

Når oppsettet av systemet er gjort, kan man sette i gang med den faktiske planleggingen. Dette gjøres ved å gå til "Planlegg" i menyen til venstre. Trykk på den måneden eller uken du vil at planen skal starte med, så på den måneden eller uken du vil planlegge frem til. Hvis du vil planlegge for en enkelt, hel måned eller uke, kan du trykke på den samme måneden/uken to ganger. Se Fig C.7.

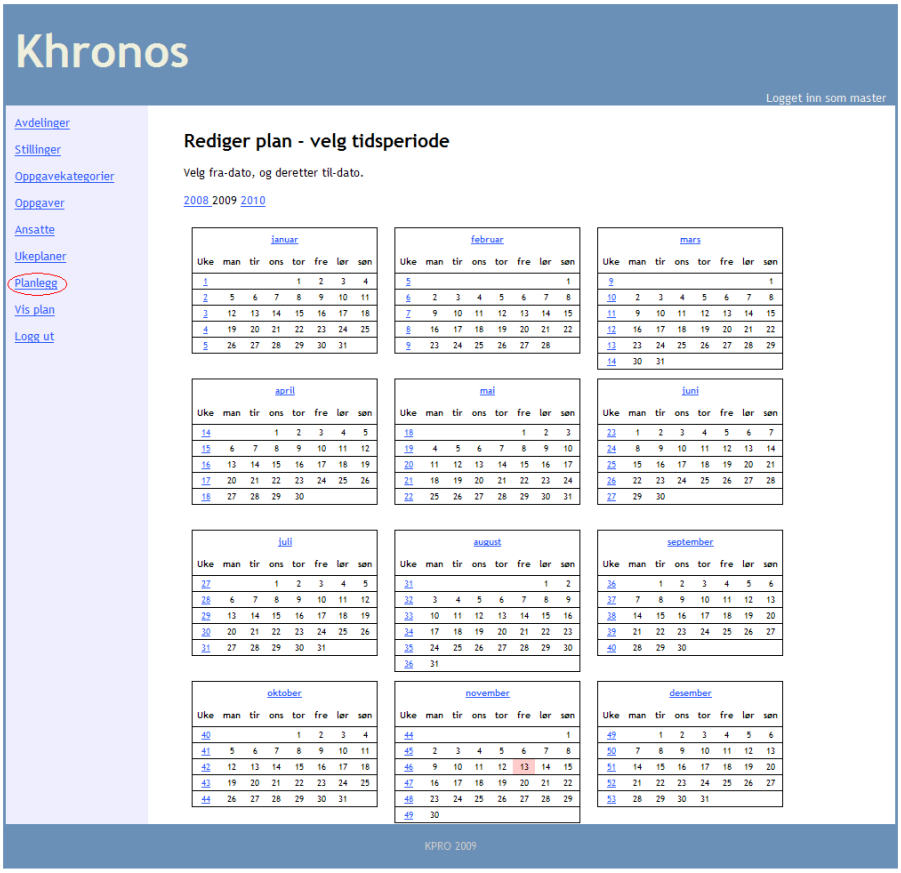

Figure C.7: Velg periode

Du har nå to valg på toppen av vinduet, "Klikk her for å auto-planlegge perioden", og "Klikk her for å slette plan for perioden". Velger du å autoplanlegge perioden, vil systemet fylle opp oppgavene som er satt til å fordeles automatisk etter hva som er mulig. Du kan så endre planen slik du ønsker. Det er også mulig å gjøre manuelle valg på en tom plan, og så velge å autoplanlegge. Systemet vil da forsøke å lage en plan rundt det du har bestemt. Velger du å slette planen, nullstiller systemet alt.

For å manuelt fjærne personer fra oppgaver på dager, må du trykke på initialene til personen på den relevante dagen, i den relevante kolonnen, og trykke "Slett" i menyen som kommer opp. For å manuelt legge til en person til en oppgave på en dag, trykk på "Legg til" i kolonne nummer to fra høyre, i den relevante dagens rad.

Du kan så velge person, og oppgave du vil sette personen til den dagen. "Tøm dag" i kolonnen lengst til høyre vil fjerne alt som er planlagt for den relevante dagen. Se Fig C.8.

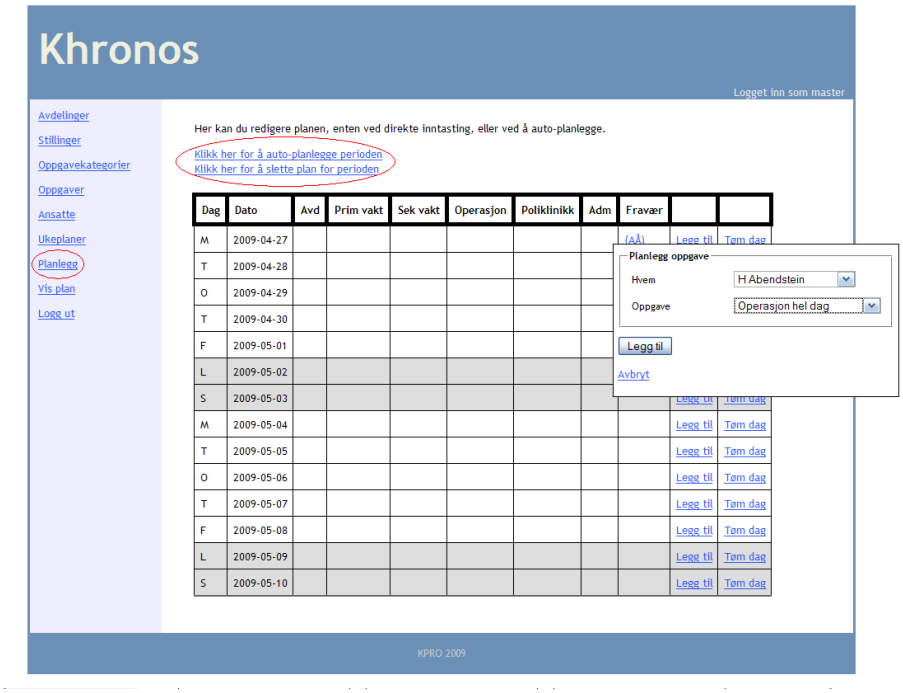

Figure C.8: Planlegging

Prøver du å utføre endringer som resulterer i konflikter i form av en person som gjør to oppgaver i samme tidsrom, vil systemet ikke utføre endringen, og informere deg om konflikten, som i Fig C.9.

Figure C.9: Konflikt

Vis Plan

For å se på en ferdig planlagt plan for en periode, gå til "Vis plan" i menyen til venstre, trykk på startmåned/uke for planen/delen av planen du vil se, og så på sluttmåned/uke. Vil du se for en enkelt måned eller uke, dobbeltklikk på denne måneden/uken. Se Fig C.10.

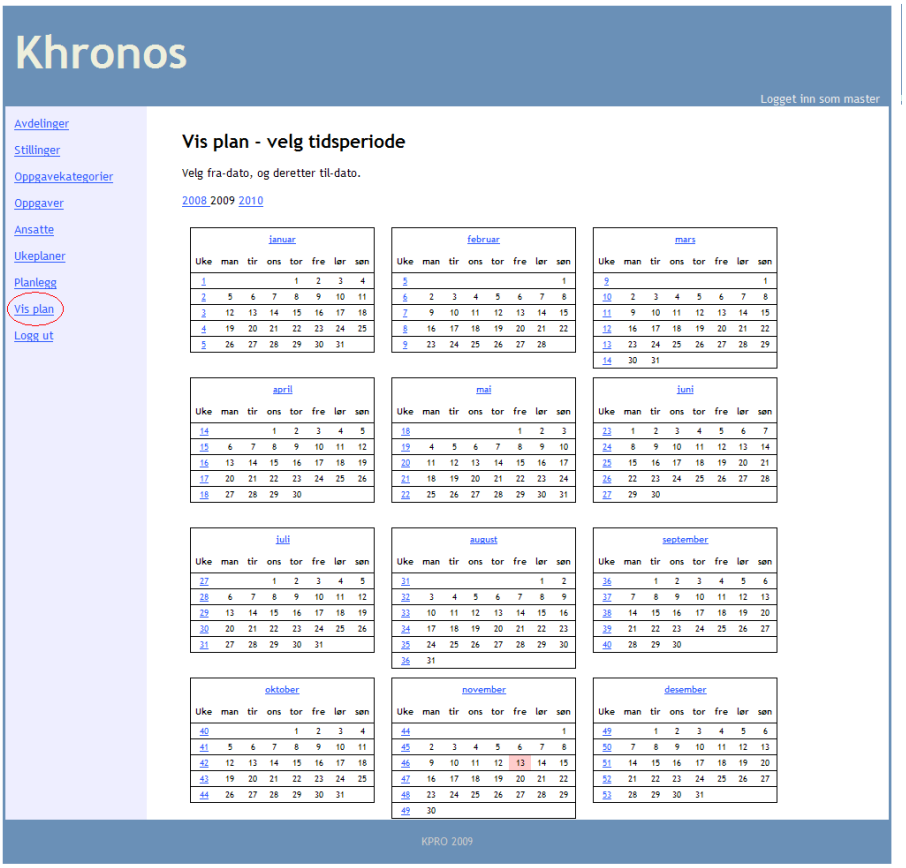

Figure C.10: Vis plan

Bruk, Bruker

Denne seksjonen dekker bruken av systemet for en vanlig bruker. Brukernavn og passord er i utgangspunktet hhv. *bruker* og *bruker*.

Vis Plan

Som vanlig bruker har du tilgang til å se på de planlagte planene. Gå til "Vis plan" i menyen til venstre, trykk på startmåned/uke for planen/delen av planen du vil se, og så på sluttmåned/uke. Vil du se for en enkelt måned eller uke, dobbeltklikk på denne måneden/uken. Se Fig C.11.

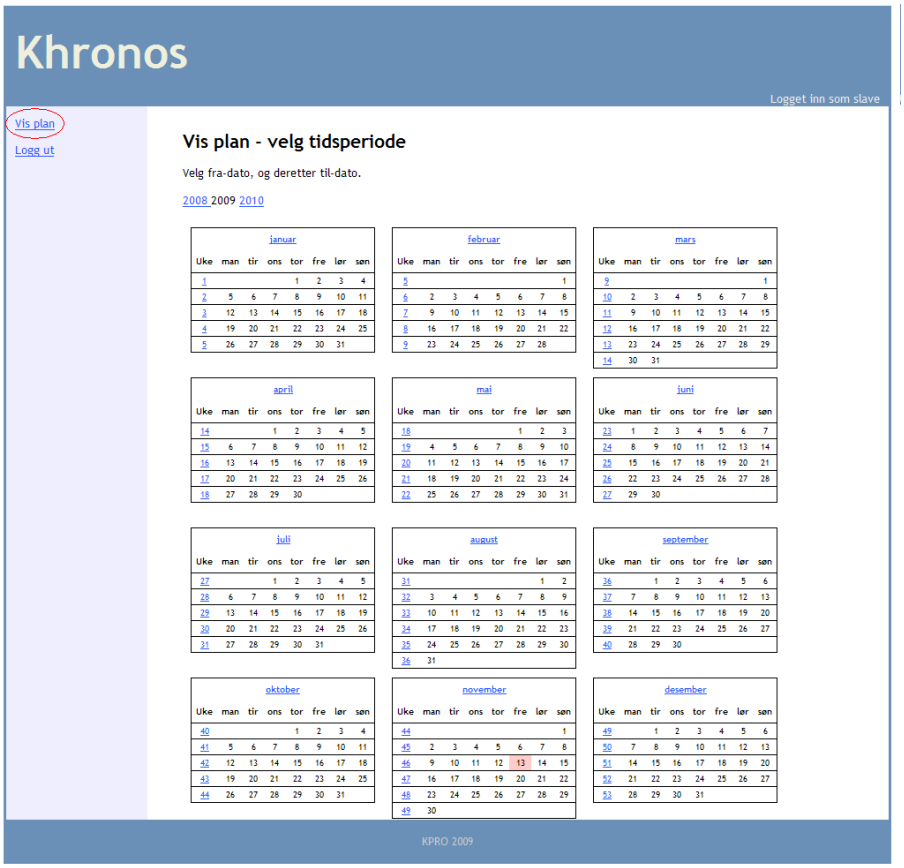

Figure C.11: Vis plan

APPENDIX D

Installation guide (Norwegian)

This Appendix is in Norwegian, as one of the requirements states that the interface should be provided in Norwegian.

Denne installasjonsveiledningen er myntet på personer som har nok teknisk kompetanse til å installere programmer, kompilere java-kode samt sette opp database. For en mer lettvint demonstrasjon av programmet, gå til `http://www.khronos.no`

Kildekode

Kildekoden ligger under mappen `source` på CD'en. Den har innstillinger for både Eclipse og NetBeans. Vi anbefaler NetBeans som IDE, siden denne kompilerer kildekoden ved hjelp av ett tastetrykk. Kopier kildemappen over til disk, og åpne prosjektet i NetBeans.

Du kan redigere kildekoden som du vil. Endringer du må gjøre:

- Configuration files/context.xml: Her spesifiseres databaseinnstillingene.
- ¡default package¿/hibernate.cfg.xml: Her spesifiseres databaseinnstillingene for Hibernate. Dersom du endrer til en annen database enn MySQL, må `dialect` spesifiseres her.
- authentication/Authentication.java: Her spesifiseres brukernavn og passord.

MySQL

Web-applikasjonen er avhengig av en database for å kunne lagre og hente data. Vi har kun testet for MySQL, men siden vi bruker Hibernate, skal du ha mange valgmuligheter. Innstillinger for bruk av database er beskrevet i forrige avsnitt. Når du har installert databasen må du sette opp selve databasen som Khronos skal bruke, samt tilordne en bruker og et passord. Dette må stemme med konfigurasjonene du gjorde i kildekoden.

Tomcat

Først må vi sette opp en web-server som kan kjøre java-servlets. Vi har kun testet dette for Tomcat, men det skal fungere for andre servere også.

Tomcat ligger i mappen `/apps/tomcat` på CD'en. Denne har også drivere den trenger for å koble til databasen. Pakk ut denne mappen til et sted på disken, f.eks. `c:/tomcat`. Det er forhåndsinstallert en utgave av web-applikasjonen, som kontakter databasen på localhost. Hvis du gjør endringer, trenger du kun å legge inn en ny utgave av `khronos.war` i mappen `tomcat/webapps`. Tomcat startes ved å kjøre `startup.bat` i mappen `tomcat/bin`

Ny utgave av Tomcat finnes på `http://tomcat.apache.org/`

Konfigurasjon

Når du starter opp Tomcat for første gang, vil Hibernate ta seg av å definere tabellene som trengs i databasen. De er da helt tomme. Du kan da følge brukerveiledningen, og taste inn data. For å fylle inn testdata vi baserte oss på fra kunden, kan du kjøre `/khronos/InsertTestData.do`.

APPENDIX E

Testing

Test Plan

This is the system test plan for this project, meant to be run upon system completion for debugging purposes, and to assess whether or not it has been completed to requirements.

Test Identifier	Sys001
Tested Feature	Logging in and out as administrator
Dependent on test(s)	None
Test Procedure	
Go to application start point. Press "Logg inn". Log in using administrator username and password, master/master by default. Confirm that the following information is available in the menu: sections, task categories, employees, positions, tasks, weekplans, plans (both planning and viewing). Select "Logg ut", confirm that user is returned to start.	
Requirement Reference ID	F12, F13

Test Identifier	Sys002
Tested Feature	Logging in and out as user
Dependent on test(s)	None
Test Procedure	
Go to application start point. Press "Logg inn". Log in using user username and password, slave/slave by default. Confirm that the following information is available in the menu: viewing the plan. Select "Logg ut", confirm that user is returned to start.	
Requirement Reference ID	F12, F13

Test Identifier	Sys003
Tested Feature	Adding entities
Dependent on test(s)	Sys001
Test Procedure	
Log in as administrator. Select departments in the menu. Add a section "TestTest". Save it. Confirm that TestTest appears in the list of departments. Select task categories in the menu. Add a category "TestTest". save it. Confirm that TestTest appears in the list of task categories. Select positions in the menu. Add a position "TestTest". Save it. Confirm that TestTest appears in the list of positions. Select week plans in the menu. Add a week plan "TestTest". Make it empty except for the name. Save it. Confirm that TestTest appears in the list of weekplans. Select employees in the menu. Add an employee "TestTest", with nessesary attributes. Make sure it is attatched to section TestTest, with the position TestTest, following the week plan TestTest. Save it. Confirm that a new employee appears in the list of employees with the correct attributes. Select tasks in the menu. Add a task "TestTest" with all nessesary attributes. Make sure it belongs to the category TestTest. Save it. Confirm that new task with correct attributes appears in list of tasks.	
Requirement Reference ID	F04, F06, F07

Test Identifier	Sys004
Tested Feature	Planning
Dependent on test(s)	Sys001, Sys003
Test Procedure	
Log in as administrator. Add a test set of departments, employees, task categories, tasks and positions. Select planning. Select a period to plan. Set the system to automatically plan the period. Confirm that a plan is made. Confirm that no doctors are set to perform more than one task at a time. Confirm that constraints on connections between tasks and doctors are maintained. Confirm that only the tasks who are supposed to be, are distributed among the employees by the system. Choose a slot with a doctor. Change this to another doctor that does not create a conflict by being placed there. Choose another slot. Change this to another doctor that does cause a conflict. Confirm that this is possible, and that the system warns the user of the conflict. Select planning again. Select the same period. Confirm that altered plan is still there. Erase the plan. Manually plan a doctor to be absent for a number of periods. Manually plan a doctor to perform some task during some period. Set the system to automatically plan the system. Confirm that the absent doctor is not set to work anywhere else in the periods he/she is set to be absent during, and that he/she is still set to be absent during said periods. Confirm that the doctor set to some task, is stil set to this task, and has not been given any tasks that conflict with this task. Select planning again. Select the same period. Confirm that the newest plan is still there.	
Requirement Reference ID	F02, F05

Test Identifier	Sys005
Tested Feature	Manual Planning
Dependent on test(s)	Sys001, Sys003, Sys004
Test Procedure	
Log in as administrator. Select planning. Select a period. If it is already planned, erase the plan. Create a new plan by hand. Make sure to include the doctor TestTest in the plan. Confirm that this is possible. Select planning, and the same period. Confirm that the manually created plan is still there.	
Requirement Reference ID	F01

Test Identifier	Sys006
Tested Feature	View Plan
Dependent on test(s)	Sys001, Sys002, Sys005
Test Procedure	
Log in as administrator. Select viewing the plan. Select a period within the period that was planned in the previous test. Confirm that the plan is there. Log out. Log in as user. Select viewing the plan. Select a period that was planned in the previous test. Confirm that the plan is there. Select the employee TestTest. Confirm that just the plan of employee TestTest is shown.	
Requirement Reference ID	F09, F10

Test Identifier	Sys007
Tested Feature	Print plan
Dependent on test(s)	Sys001, Sys002, Sys005, Sys006
Test Procedure	
Log in as administrator. Select viewing the plan. Select printing the plan. Confirm that the plan, and only the plan, is sent to print. Log out. Log in as user. Select viewing the plan. Select print. Confirm that the plan, and only the plan, is sent to print.	
Requirement Reference ID	F11

Test Identifier	Sys008
Tested Feature	Editing entities
Dependent on test(s)	Sys001, Sys003, Sys005
Test Procedure	
Log in as administrator. Select sections. Find the section TestTest in the list of sections. Select edit. Change the name to "TestTestTest". Save it. Confirm that the department TestTest has become TestTestTest, and that all references to TestTest in the rest of the system have become TestTestTest. Select task categories. Find the task category TestTest, and edit it. Change the name from "TestTest" to "TestTestTest". Confirm that the task category TestTest is now TestTestTest, and that all referenses to TestTest in the rest of the system have become TestTestTest. Select positions, find TestTest in the list of positions, edit it, and change it to "TestTestTest". Save it. Confirm that the position TestTest is now called "TestTestTest" and all references to TestTest in the rest of the system have become TestTestTest. Select tasks, find TestTest in the list of tasks, edit it. Change from "TestTest" to "TestTestTest", and save it. Confirm that the task TestTest has become TestTestTest, and that all references to TestTest in the rest of the system. Select week plans, find TestTest in the list of week plans. Edit it. Change the name to "TestTestTest". Confirm that the plan TestTest has become TestTestTest, as well as all references to the plan in the rest of the system have become TestTestTest. Select employees, find TestTest in the list of employees, edit it, and change it to TestTestTest. Save it, and confirm that the employee TestTest has become TestTestTest, and that all references to TestTest in the rest of the system have become TestTestTest.	
Requirement Reference ID	F04, F06, F07

Test Identifier	Sys009
Tested Feature	Deleting entities
Dependent on test(s)	Sys001, Sys003, Sys005, Sys008
Test Procedure	
Log in as administrator. Select sections. Find the section TestTestTest in the list of departments. Delete it. Confirm that it is not possible to delete section, as there are employees attatched to it. Select positions. Find TestTestTest. Delete it. Confirm that it is not possible to delete, as there are employees using it. Select task categories. Find TestTestTest. Delete it. Confirm that it is not possible to delete the task category, as there are tasks belonging to it. Select tasks. Find TestTestTest. Delete it. Confirm that all references to the task TestTestTest are removed from the plan and from the rest of the system. Select week plans, find TestTestTest, delete it. Confirm that the week plan cannot be deleted as an employee is set to follow it. Select employees. Find TestTestTest. Delete it. Confirm that all references to the employee TestTestTest in the plan and the rest of the system have been removed. Select tasks. Delete all tasks belonging to the category TestTestTest. Select task categories. Find TestTestTest. Delete it. Confirm that the task category TestTestTest has been removed from the list of task categories, and that all references to it have been removed from rest of the system. Select employees. Delete all employees with the posision TestTestTest, and/or belonging to the section TestTestTest, and/or following the week plan TestTestTest. Select week plans, find TestTestTest, delete it. Confirm that the week plan TestTestTest is gone from the list of week plans, and the rest of the system. Select positions. Find TestTestTest. Delete it. Confirm that all references to the position TestTestTest have been removed from the rest of the system. Select sections. Find TestTestTest. Delete it. Confirm that all references to the department TestTestTest have been removed from the rest of the system.	
Requirement Reference ID	F04, F06, F07

Test Identifier	Sys010
Tested Feature	Setting a doctor to fixed tasks
Dependent on test(s)	Sys001, Sys003, Sys004, Sys006
Test Procedure	
Log in as administrator. Select week plans. Add a week plan, name it Test, make it department independent. Fill it with tasks. Save it. Select employees. Add the employee Test, following the week plan Test. Select planning. Select a period, and set the system to automatically plan it. Confirm that the employee Test is set to perform all the tasks in the weekly plan Test.	
Requirement Reference ID	F08

Test Identifier	Sys011
Tested Feature	Attatching two doctors for a period
Dependent on test(s)	Sys001
Test Procedure	
Log in as administrator. Clean all info from the system, reinsert test data. Go to employees. Take any employee, and attatch another employee for a certain time period. Go to planning, select the same time period as the period in which the two employees are attatched. Set the system to automatically plan the period. Confirm that the two employees are placed together in the taks that are automatically distributed by the system, wherever this is possible.	
Requirement Reference ID	F03